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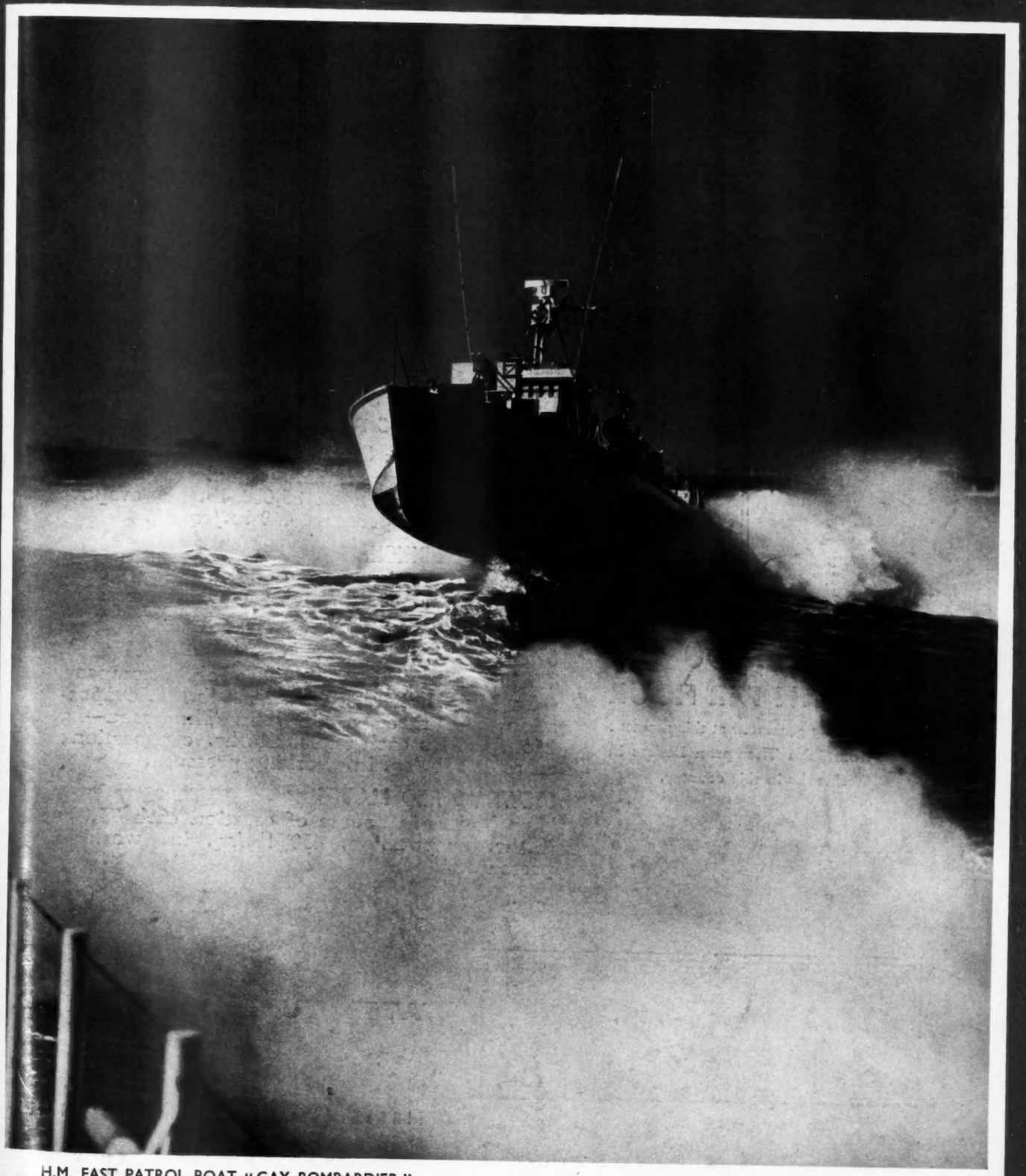

H.M. FAST PATROL BOAT "GAY BOMBARDIER."

MOST OF THE LARGE STEEL FIRMS ARE INSTALLING JOHN THOMPSON WATER TUBE BOILERS

2,500,000 lb.
STEAM PER HOUR
is being generated at this moment from John Thompson Boilers in Steelworks in this country.

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Three boilers (first contract) and one boiler (repeat order) now steaming, with a second repeat order under erection. Each boiler 100,000 lb./hr. normal evaporation, 125,000 lb./hr. M.C.R.; working pressure 450 lb./sq. in.

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Two boilers in course of erection each 75,000 lb./hr. evaporation, 450 lb./sq. in. working pressure.

JOHN THOMPSON
Over a Century of Boiler Making

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ELECTRIC LOCOMOTIVES OF AMERICAN DESIGN FOR THE NETHERLANDS RAILWAYS.

ELECTRIC traction was inaugurated on the Netherlands Railways in 1908, when the main line between Rotterdam and The Hague and Scheveningen was converted on the 750-volt direct-current overhead system. Ten years later the Amsterdam-Rotterdam section was electrified on the 1,500-volt direct-current system, and in 1932 a similar conversion was effected on The Hague-Rotterdam-Utrecht-Arnhem and Amsterdam-Utrecht-Eindhoven lines. In 1944, the whole railway system of the country was pillaged by the Germans, but on the cessation of hostilities restoration was rapidly carried out and electrification was extended, the result being that at the present time 800 miles out of a total route mileage of nearly 2,000 are being operated by this method.

FIG. 1. LOCOMOTIVE LEAVING THE HAGUE WITH PASSENGER TRAIN.

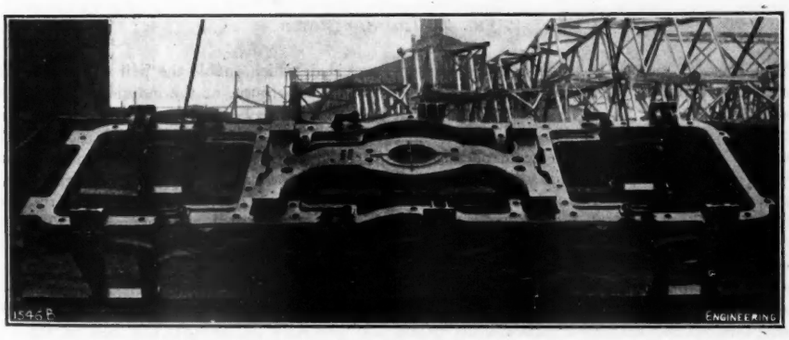


FIG. 2. CAST-STEEL BOGIE FRAME.

Until 1947, only passenger traffic was handled in electrical multiple-unit stock, steam still being used to deal with the goods traffic, even on the lines that had been converted. As, however, these lines included some of the major freight transport routes it was decided to employ electric locomotives. The prototype British-built Bo + Bo mixed traffic locomotive, which was intended for use on the Manchester-Sheffield-Wath section of the former London and North Eastern Railway, was first used for this purpose, and since it was sent to Holland in 1947 it has run some 335,000 miles hauling both passenger and goods trains, particularly between Amsterdam and the south of the country. It is satisfactory to be able to record that it has performed this duty without exhibiting any failure that can be attributed either to faulty design or workmanship; although, as might be expected, some modifications have had to be made in what was more or less an experimental layout. At a later date a number of locomotives similar to those which are in use on the French railways have been taken into service, and others have been ordered from Switzerland and from the Dutch licensee of an American firm, shortage of British currency preventing them from being obtained from this country.

NEW DESIGNS.

The French locomotives comprise 50 Bo + Bo units, each of which weighs 77 tons and is capable of developing 2,710 h.p. on the one-hour rating; and ten Co + Co locomotives, which weigh 108 tons and develop 4,050 h.p. under the same conditions, the maximum speed being 87 m.p.h. These locomotives, the design of which generally conforms with current French practice, were built by Alsthom of Belfort.* The traction motors are, however, wholly suspended and drive the axles through that firm's floating-ring Silentbloc transmission, while in the case of the similar locomotives used in France the motors are nose-suspended. The ten Swiss locomotives weigh 98 tons and have an output of 4,420 h.p. at the one-hour rating. They were designed by the Swiss Locomotive and Machine Works, Winterthur, and the Oerlikon Company, although some of them were constructed in Holland. Finally, 25 Co + Co locomotives have been designed for European conditions by the Baldwin Locomotive Works, Philadelphia, and the Westinghouse Electric and Manufacturing Company, Pittsburgh, but, with the exception of the cast-steel bogie frames and a few other parts, they are being constructed in Holland, the mechanical portion by Werkspoor, Utrecht, and the electrical equipment by Heemaf, Hengelo.

* See ENGINEERING, vol. 175, page 641 (1953).

AMERICAN LOCOMOTIVE.

These American-designed locomotives are 59 ft. 4 in. long over the buffers, have a total wheelbase of 45 ft. 9 in., and an overall width of 10 ft. 1 in. The height of the roof above the rails is 13 ft. The mechanical portion weighs 75 metric tons and the electrical equipment 44 metric tons, of which 20 metric tons is accounted for by the motors, giving a total weight of 119 tons. They have a typical American silhouette, as will be clear from the photograph reproduced in Fig. 1. The frame consists of two longitudinal members of H-section and two V-section cross-beams. These four parts are rigidly connected by subsidiary members and reinforcing plates. The buffers and drawgear at each end are mounted on two vertical steel plates. The ends of the main longitudinal members have been strengthened so as to ensure the efficient transmission of the tractive and braking stresses, and the members have been designed to offer a constant resistance to bending moments over their whole length. Welding is used throughout, the welds being strong enough to resist heavy compression, in accordance with the American Postal Car regulations. The superstructure consists of uprights, which were also assembled by welding and are attached to the frame by the same method. The resulting structure is covered with steel sheets. The noses in front of the cabs are formed of two vertical members, which are strengthened by posts and steel plating, the whole being welded together and to the frame, so as to provide an exceptionally rigid structure.

The frame is supported on two three-axle bogies, through the medium of H-bolsters and double semi-elliptical springs, the design being similar to that of those used on American Diesel-electric locomotives. The frame of the bogie, which is illustrated in Fig. 2 with the bolster in position, consists of a single steel casting in which the bearings for the brake gear are incorporated, and was delivered from the foundry in such a condition that very little subsequent machining was necessary. It is supported on the axleboxes by helical springs and goose-neck balance arms, the suspension being of the well-known Pennsylvania type. The axleboxes are equipped with double-spherical roller bearings. The flanges of the wheels on the central axle of each bogie are not so thick as on the others, in order to facilitate the negotiation of sharp curves. The axles have no lateral play. Brakes are provided on each wheel, the operating cylinders being mounted outside the bogies.

ARRANGEMENT OF EQUIPMENT.

The locomotive body comprises a nose compartment, driver's cab and ventilating compartment at each end, with a central equipment compartment in the middle. Each nose compartment contains a compressor, which is driven by a 13½-h.p. motor and supplies air for braking and for the main control equipment, while the driver's cabs contain a master controller, switch and meter panels and brake valves. The main driving position is on the right of the cab, but an auxiliary driving position is also provided on the left for use during shunting. The ceilings and walls of the cabs, access to which is obtained through a rear door, are sound-proofed, and sash windows are provided through which the

driver can lean while seated. Each ventilating compartment contains a 20-h.p. motor which is connected to a centrifugal blower with an output of 7,000 cub. ft. of air per minute. One of these sets is also coupled to a direct-current generator for charging the battery, and the other to a fan which supplies air for cooling the starting resistances. Air is drawn in through filters to trap both dust and moisture, and in service both compartments are under a slight vacuum.

The central compartment is approached through the ventilating compartments and two side corridors, which form a means of access between the two drivers' cabs. It contains the main control equipment, including contactors, relays, resistances and shunts, all of which is mounted in blocks on frames, as shown in Fig. 3, so that it can be assembled externally and lowered into position through an opening in the roof. The high-tension equipment is installed in two L-shaped recesses, one containing the relays, switches and contactors, and the other the field shunts and starting resistances, the latter being ventilated through openings in the side walls and roof. The main starting contactors are arranged in two rows along the walls of the compartment, so that they are accessible for maintenance from both sides. Normally, this portion of the locomotive is closed and cannot be opened until the pantographs have been lowered and the traction circuit earthed.

Traction is provided by six 750-volt motors, each of which has a continuous rating of 493 h.p. when its field is shunted to a maximum of 58 per cent. They are designed to give a maximum track speed of 87 m.p.h. and are nose-suspended. This is a radical departure from current European practice, although the method is extensively used in the United States on Diesel-electric locomotives. Although the dynamic forces on the rail are, of course, increased in this way, it is not considered that on a well-laid track, such as is normally found in Holland, the stresses will much exceed those set up by unbalanced steam locomotives or by the nose-suspended motors of fast multiple-unit trains.

The motors themselves, one of which is shown in Fig. 4, are provided with four main and four auxiliary poles, but not with compensation windings, while the armature slots are of Westinghouse design. Special attention has been paid to the construction of the commutator so as to increase its life and reduce its maintenance. For this reason a special copper alloy with low-wearing properties has been used for the segments and pressure is evenly and constantly maintained on the surface by a circular spring. The brushes are of tripartite design, thus ensuring greater contact area and reduced wear. The armatures run in roller bearings and drive the axles through spur gearing. The axlebox bearings are protected from pitting by conducting the return currents to the rails through brushes.

CONTROL ARRANGEMENTS.

The motors are connected in pairs, the two forming a pair being permanently coupled in series. The three groups thus formed can then be connected either in series, series-parallel or parallel, as required, by operating electro-pneumatic contactors, which are controlled by the same levers as those provided for cutting out the starting resistances. Change-over from one system of connection to another is effected by the shunt method. When the motors are connected in series, 15 starting notches are available, while ten are provided for series-parallel and eight for parallel operation. There are also three shunt notches on each system of connection, whereby resistances and reactances are brought into circuit and shunt percentages of 33 per cent., 50 per cent. and 58 per cent. obtained. There are therefore 12 economical running positions.

ELECTRIC LOCOMOTIVE FOR DUTCH RAILWAYS.

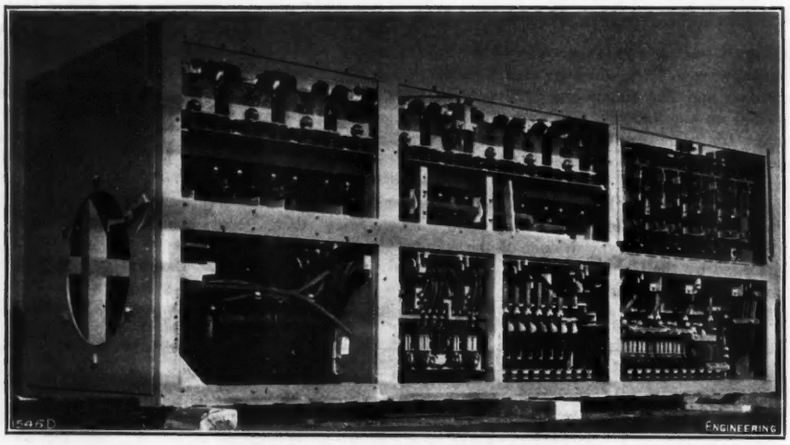


FIG. 3. CONTROL EQUIPMENT MOUNTED IN A BLOCK.

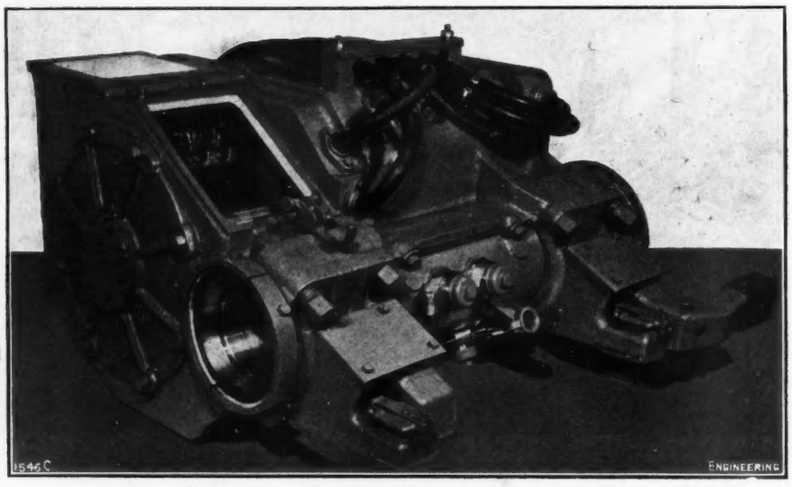


FIG. 4. TRACTION MOTOR.

The traction circuit is controlled by electro-pneumatic contactors, the operating valves of which are supplied from a 30-cell iron-nickel battery at 48 volts. The necessary low-tension circuits are opened and closed by the master controllers in the driver's cabs, while a push-button allows the 48-volt supply to the main contactors to be cut-off in emergency. These controllers, which are actuated by levers, are of the rotating cam-shaft type with silver-tipped contacts. Both these contacts and the main contactors are equipped with interlocks. The field-shunting contactors are controlled by a second lever on the master controllers, while a third lever is provided for operating the reversing switches.

Current from the overhead line is collected through dual pantographs of the Faiveley type, each of which carries a double shoe with three rows of carbon inserts. Protection against lightning is provided by arresters of the condenser type. The pantographs are connected through a roof 'bus-bar, main fuse and three groups of two line switches in series to the three groups of starting resistances. These resistances are, in turn, connected to the traction motors through switches, of which there are three in series for each group when full parallel operation is in use. These switches are fitted with over-current and no-voltage relays and can also be operated by relays in the control and train heating circuits. In addition to the contactors already mentioned, four motor cut-out switches are provided, which enable the pair of motors forming two of the groups, or the individual motors in the other group, to be disconnected. Current for train heating is also obtained direct from the pantographs through fuses, while the compressor and blower motors are similarly supplied through fuses and electromagnetic contactors, the same arrangement being used on the cab-heating circuits. The 48-volt auxiliary circuit mentioned above is also used to supply the lighting system, which is under the control of the driver through switches provided with over-load protection. The lighting circuits are generally un-earthed, but two of the signal-lamps are connected in series with the central point earthed, so that if a fault occurs one lamp is extinguished and the other becomes exceptionally bright.

During exhaustive trials these locomotives, we understand, have proved their ability to deal with the traffic and have shown themselves capable of starting heavy trains under difficult conditions, a result which is doubtless made possible by their high adhesive weight. The locomotives in service are now hauling express passenger trains at speeds up to 78 m.p.h., and coal trains with loads up to 1,600 tons at a maximum speed of 37·5 m.p.h. The riding qualities are reported to be good at all speeds. During tests at the Heemaf works the motors showed excellent commutation both on heavy loads and when the demand was fluctuating.

COLLAPSING LOAD OF A STRUT WITH ELASTICALLY-FIXED ENDS.

By DR.-ING. M. J. GERCKE.

THE fundamental formulæ generally attributed to Euler give the buckling load, P, of a prismatic column or strut, of length l, for ideal cases of the end conditions only. Thus, the following equation, which will be taken as a basis of reference,

$$P = \pi^2 \frac{E I}{l^2}, \quad . \quad . \quad (1)$$

where E I is the flexural rigidity (assumed to be uniform throughout the length of the strut), is valid only for freely hinged ends in fixed positions, that is, both ends are free to take up any inclination but are unable to move laterally. For the other three possible cases of ideal end conditions—one end rigidly fixed and the other either completely free or fixed in space but free to take up any inclination, or thirdly, both ends rigidly fixed in position and direction—the coefficient π^2, in equation (1), has to be replaced by $\frac{\pi^2}{4}$, $2 \cdot 04\,\pi^2$ or $4\,\pi^2$, respectively. Since these ideal cases are never fully realised in practice, when applying Euler's formulæ to actual struts it is necessary to use either, one of the ideal expressions which might be expected to give the best approximation or, alternatively, to guess an intermediate value of the coefficient for $\frac{E I}{l^2}$. Hence, a generalised form of Euler's formula, in which the coefficient

$$\phi = \frac{P l^2}{E I}, \quad . \quad . \quad . \quad (2)$$

is a given function of the end conditions, will afford a means of developing the calculations involved in the design of the struts. Attempts to derive such a general form, however, were apparently not undertaken for 170 years after Euler had published his work in 1744, and then the results were most complicated. An attempt to arrive at a convenient expression for ϕ is made in the following article. A brief discussion is also given of the theoretical implications of the expressions obtained; ϕ may be termed the "specific collapsing load."

Fig. 1. NOTATION.

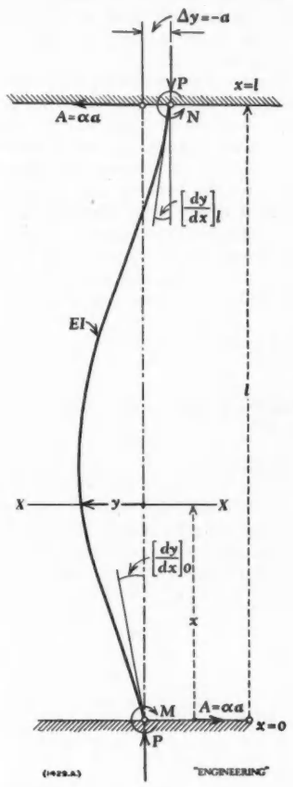
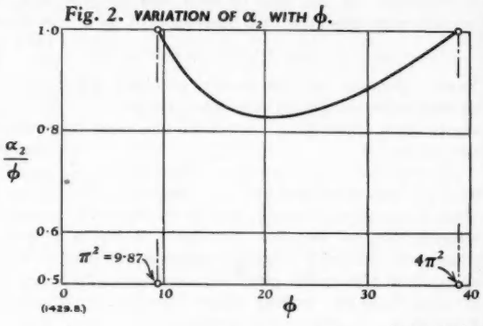


Fig. 2. VARIATION OF α_2 WITH ϕ.



DERIVATION OF AN EXPRESSION FOR THE "SPECIFIC COLLAPSING LOAD."

Consider the buckling of the strut shown in Fig. 1, herewith, the ends of which are elastically hinged and free to move laterally, relative to each other, against a certain elastic resistance. This kind of fixing involves, if the ends take up an angular position, reactive end moments, M and N, that are proportional to the slopes of the bending line at the points of fixture, such that

$$M = K_a \left[\frac{dy}{dx}\right]_{x=0} \text{ and } N = -K_b \left[\frac{dy}{dx}\right]_{x=l},$$

where x and y are the co-ordinates of the strut, as shown in Fig. 1, and K_a, K_b are coefficients that represent the end moments due to an end inclination, $\frac{dy}{dx}$, equal to unity. Furthermore, for a relative shift Δy between the ends, reactive forces, A, are called into play, such that at the end, $x = l$,

$$A = -K_c \Delta y,$$

where K_c is the elastic constant for unit shift between the ends. These several fixing conditions can be expressed in a general way by the following dimensionless parameters,

$$\mu = K_a \frac{l}{E I}, \quad \nu = K_b \frac{l}{E I}, \quad (3), (4)$$

and

$$\alpha = K_c \frac{l^3}{E I}. \quad . \quad . \quad . \quad (5)$$

The possible values of the coefficients of "angular fixing," μ or ν, may lie anywhere between infinity and zero; μ or $\nu = \infty$ is the limiting case appropriate to a fixed end clamped so as to constrain the alignment of the strut at that point, and μ or $\delta = 0$ is the case of an end free to take up any inclination. The possible values of the coefficient of "lateral fixing," α, likewise range from infinity to zero, $\alpha = \infty$ corresponding to ends fixed in their relative position and $\alpha = 0$ to ends free to move laterally. For struts that will not in practice exactly fulfil the conditions of being absolutely fixed or free at the ends, μ, ν and α will have intermediate finite values according to the values of K_a, K_b and K_c, respectively.

In order to deduce the differential equation of the bending line of the strut, it is necessary to consider the conditions under which the strut will be deflected under the sole action of a perfectly axially applied compressive load, P, this being the critical load which just brings about instability. The strut concerned is assumed to be long in proportion to its cross-sectional dimensions, initially perfectly straight, and homogeneous in the quality of the material from which it is made. Under the action of P and its own flexural elastic resisting forces, let the strut reach a state of equilibrium when it takes up the form of the curve indicated in Fig. 1; then, neglecting the effects of end compression and using the conventional relationships derived for ordinary transverse bending, the curvature may be expressed as

$$\frac{d^2y}{dx^2} = -\frac{M_x}{E I}, \quad . \quad . \quad . \quad (6)$$

where M_x is the bending moment at a point distance x from the end taken as the origin; this moment is given by

$$M_x = P y + A x - M. \quad (7)$$

For equilibrium,

$$M - N - Al + Pa = 0, \quad . \quad (8)$$

provided that, with the relative shift of the ends of the strut, the lines of action of the thrusts, P, are similarly displaced by a distance, $-a$. Hence, with $\frac{N}{M} = z$, from equations (7) and (8),

$$M_x = P y + A x - \frac{A l - P a}{1 - z}, \quad . \quad (9)$$

or, putting $A = -K_c \Delta y$, and multiplying throughout by $\frac{l^2}{E I}$,

$$\frac{M_x l^2}{E I} = \phi y - \alpha \Delta y \frac{x}{l} + \frac{\alpha \Delta y + \phi a}{1 - z}. \quad (10)$$

Substituting this last equation back in equation (6) gives a differential equation describing the bending line; thus,

$$\frac{d^2y}{dx^2} + \frac{\phi}{l^2} y - \frac{1}{l^2}\left(\alpha \Delta y \frac{x}{l} - \frac{\alpha \Delta y + \phi a}{1 - z}\right) = 0. \quad . \quad . \quad . \quad (11)$$

The solution of this equation, assuming $y = 0$ at $x = 0$, is

$$\frac{y}{a} = -\frac{\frac{\alpha \Delta y}{\phi a} + 1}{1 - z}\left(1 - \cos \frac{x}{l}\sqrt{\phi}\right) + C \sin \frac{x}{l}\sqrt{\phi} + \frac{\alpha \Delta y}{\phi a}\frac{x}{l}, \quad (12)$$

where C is a constant of integration. This equation represents the deflected curve of the buckling strut, although the expression still contains the, as yet, undetermined value of the specific collapsing load, ϕ. With that value of ϕ inserted in the equation, equation (12) then complies with the conditions of elastically unstable equilibrium that have been stated previously.

Equation (12) now has to be amended to satisfy the two following end conditions. Firstly, for $x = l$,

$$y = y_l = -a, \quad . \quad . \quad (13)$$

(It must be emphasised that this does not mean that the end of the strut has to be deflected by a definite amount, a, but indicates no more than the assumption that the displacement of the lines of action of P is equal to the relative shift Δy; for this reason, the term a does not appear any more in the end-condition equations given below.) Secondly, from equation (6) and at $x = 0$, $x = l$, respectively,

$$-\frac{d^2y}{dx^2} E I = -M = -K_a \left[\frac{dy}{dx}\right]_{x=0},$$

and

$$-\frac{d^2y}{dx^2} E I = -N = K_b \left[\frac{dy}{dx}\right]_{x=l}.$$

Substituting from equations (3) and (4) in these last two expressions gives

$$\mu \left[\frac{dy}{dx}\right]_0 - l \left[\frac{d^2y}{dx^2}\right]_0 = 0, \quad . \quad (14)$$

and

$$\nu \left[\frac{dy}{dx}\right]_l + l \left[\frac{d^2y}{dx^2}\right]_l = 0. \quad . \quad (15)$$

Substituting the values of y and its derivatives,

obtained and deduced from equation (12), in equations (13), (14) and (15), and writing

$$\frac{\frac{\alpha}{\phi}-1}{1-z}=Z, \quad . \quad . \quad (16)$$

the three following primary end-condition equations are obtained:

from equation (13),

$$C\sin\sqrt{\phi}-\left(\frac{\alpha}{\phi}-1\right)+\left(1-\cos\sqrt{\phi}\right)Z=0, \quad . \quad . \quad . \quad (17)$$

from equation (14),

$$C-\frac{\alpha}{\phi\sqrt{\phi}}-\frac{\sqrt{\phi}}{\mu}Z=0, \quad . \quad (18)$$

and from equation (15),

$$C\left(\cos\sqrt{\phi}-\frac{\sqrt{\phi}}{\nu}\sin\sqrt{\phi}\right)-\frac{\alpha}{\phi\sqrt{\phi}}+\left(\frac{\sqrt{\phi}}{\nu}\cos\sqrt{\phi}+\sin\sqrt{\phi}\right)Z. \quad (19)$$

These three must be fulfilled simultaneously and this cannot be effected by merely choosing a suitable value of the constant of integration C. Moreover, it is necessary that a certain relationship, specified below, shall obtain between ϕ and the three parameters, μ, ν and α; the value of ϕ which satisfies this relationship is the specific collapsing load that gives the actual critical load, P, according to equation (2). To determine this condition for ϕ, C must be eliminated by substituting in equations (17), (18) and (19), the values of C that are obtained from (18), (19) and (17), respectively. This gives a series of three secondary end-condition equations that are independent of C:

$$\frac{\alpha}{\phi\sqrt{\phi}}-\left(\frac{\alpha}{\phi}-1\right)\operatorname{cosec}\sqrt{\phi}+m\,Z=0. \quad (20)$$

$$\frac{\alpha\,n}{\phi\sqrt{\phi}}+[m\,n-(m+n)\operatorname{cosec}\sqrt{\phi}]\,Z=0. \quad (21)$$

$$-\frac{\alpha}{\phi\sqrt{\phi}}+\left(\frac{\alpha}{\phi}-1\right)\left(\operatorname{cosec}\sqrt{\phi}-n\right)+n\,Z=0, \quad . \quad . \quad . \quad (22)$$

where

$$m,n=\frac{1-\cos\sqrt{\phi}}{\sin\sqrt{\phi}}+\frac{\sqrt{\phi}}{\mu,\nu}. \quad . \quad (23)$$

If any two of these secondary end-condition equations (that is, equations (20), (21) and (22)) are valid simultaneously—which is the necessary, but sufficient, condition—then all three primary end conditions (equations (17), (18) and (19)) are satisfied, together with the fourth assumption that $y_0=0$. Eliminating Z from any two of the equations (20), (21) or (22) gives the final expression for ϕ, namely,

$$\left(1-\frac{\alpha}{\phi}\right)\left(m\,n-\frac{m+n}{\sin\sqrt{\phi}}\right)-\frac{\alpha}{\phi}\frac{m+n}{\sqrt{\phi}}=0. \quad (24)$$

A general formula has therefore been derived from which the specific collapsing load, ϕ, that is, the coefficient in the generalised Euler formula, equation (2), can be obtained for any given conditions of μ, ν and α.

Discussion of the General Formula.

On considering the general formula for the specific collapsing load, equation (24), it is found that the equation is symmetrical in μ and ν; this could have been foreseen, since it is immaterial to the buckling of the strut that the clamping at one end should correspond to μ and to ν at the other, or vice versa. Furthermore, using values for m and n obtained from equation (23) and, at the same time, writing

$$\frac{\sqrt{\phi}}{\tan\sqrt{\phi}}=p \quad \text{and} \quad \frac{\tan\left(\frac{\sqrt{\phi}}{2}\right)}{\frac{\sqrt{\phi}}{2}}=q, \quad . \quad . \quad . \quad (25),\ (26)$$

equation (24) can be re-written as

$$\phi-(\mu+\nu)\,p-\mu\nu-\frac{\alpha}{\phi}[\phi-(\mu+\nu)(p-1)-\mu\nu(1-q)]=0, \quad (27)$$

from which the special cases of $\alpha=\infty$ and $\alpha=0$ may be deduced; transpose equation (27) and re-write thus,

$$\alpha=\phi\,\frac{\phi-(\mu+\nu)\,p-\mu\nu}{\phi-(\mu+\nu)(p-1)-\mu\nu(1-q)}. \quad (28)$$

In the case of the ends of the strut being fixed in position ($\alpha=\infty$), the denominator in the last equation must have the value of zero and the following relationship must hold good:

$$\phi-(\mu+\nu)(\sqrt{\phi}\cot\sqrt{\phi}-1)-\mu\nu\left(1-\frac{2}{\sqrt{\phi}}\,\frac{1-\cos\sqrt{\phi}}{\sin\sqrt{\phi}}\right)=0. \quad (29)$$

Alternatively, in the case of ends free to shift laterally with respect to each other ($\alpha=0$), then

$$\phi-(\mu+\nu)\sqrt{\phi}\cot\sqrt{\phi}-\mu\nu=0. \quad (30)$$

Euler's formulæ can be readily obtained from equations (29) and (30) by considering the particular cases where either μ or ν, or both, are taken as zero or infinity.

The variation of the specific collapsing load, ϕ_1 with α is best considered in terms of equation (28). When α has the value zero, ϕ has the value given by equation (30), and equation (28) shows that ϕ increases with increasing values of α and asymptotically approaches the value given by equation (29). Between these two limiting values there is a condition of $\phi=\alpha$, and for this particular value of α, denoted by α_1,

$$\tan\left(\frac{\sqrt{\alpha_1}}{2}\right)=-\frac{\sqrt{\alpha_1}}{2}\,\frac{\mu+\nu}{\mu\nu}. \quad (31)$$

A more valuable investigation is a discussion of the effect of variations in the ratio of the end moments, z; from equation (16) it follows that

$$z=1-\frac{\frac{\alpha}{\phi}-1}{Z}. \quad . \quad . \quad (32)$$

From equation (20),

$$Z=-\frac{1}{m}\left[\frac{\alpha}{\phi\sqrt{\phi}}-\left(\frac{\alpha}{\phi}-1\right)\operatorname{cosec}\phi\right], \quad (33)$$

and substituting this value in equation (32) gives

$$z=\frac{\frac{\alpha}{\phi\sqrt{\phi}}-\left(\frac{\alpha}{\phi}-1\right)\left(\cot\sqrt{\phi}-\frac{\sqrt{\phi}}{\mu}\right)}{\frac{\alpha}{\phi\sqrt{\phi}}-\left(\frac{\alpha}{\phi}-1\right)\operatorname{cosec}\sqrt{\phi}}. \quad . \quad . \quad . \quad (34)$$

On considering the variation of z with α for given values of μ, ν, and assuming $\mu\geqq\nu$ (as is assumed in all the following deductions) it is found that, for the upper limit $\alpha=\infty$, z has the asymptotic value

$$z_\infty=\frac{1-\sqrt{\phi}\left(\cot\sqrt{\phi}-\frac{\sqrt{\phi}}{\mu}\right)}{1-\sqrt{\phi}\operatorname{cosec}\sqrt{\phi}}<1, \quad (35)$$

where ϕ has the particular value corresponding to $\alpha=\infty$, which has been obtained from equation (29). With decreasing values of α, z increases, having the particular value of $+1$ for $\alpha=\alpha_1=\phi$, and increasing further to reach the value of infinity when α has the special value α_2, which is determined below. As α decreases yet further, z increases from a value of $-\infty$ to

$$z_0=-\left(\frac{\sqrt{\phi}}{\mu}\sin\sqrt{\phi}-\cos\sqrt{\phi}\right)>-1, \quad . \quad . \quad . \quad (36)$$

where ϕ has the particular value corresponding to $\alpha=0$, which is obtained from equation (30); z has the value -1 when $\phi=\pi^2$. The special degree of lateral fixture, α_2, mentioned above, corresponding to an infinite value of z, can be found from the condition that the denominator in equation (34) shall be zero; this condition gives

$$\alpha_2=\frac{\phi}{1-\frac{\sin\sqrt{\phi}}{\sqrt{\phi}}}. \quad . \quad (37)$$

This expression should be considered in conjunction with the curve in Fig. 2, on page 67. Suppose that a value of ϕ, say, ϕ_1, has been obtained for given values of μ, ν and α according to equation (27); this value ϕ_1 is then substituted in equation (37) and a value of α_2 calculated. If the value of α_2 so found is equal to the value of α which was used in equation (27) to obtain ϕ_1, then this degree of lateral fixity is the special degree referred to above.

According to the sign of z, which changes when $\alpha=\alpha_2$ and $z=\pm\infty$, there are two potential types of buckling line: (*a*) for values of α between ∞ and α_2, when the end moments, M and N, both have the same sign and act in counter directions, and when both moments tend to counteract the deflection, the main feature of the resulting bending line of the buckling strut is that the middle portion of the strut has a deflection line of the C-type, as shown in Figs. 3 and 4, opposite, and in the Table, below; (*b*) for values of α less than α_2, when the end moments have opposite signs and act in the same direction, so tending to influence the deflection in contrasting ways, the bending line in this instance is characterised chiefly by the lateral shift at the ends, and is of the S-type shown in Fig. 5. For both types, the deflection is given by equation (12), which, with $\Delta y=-a$ and introducing Z as denoted in equation (16), can be re-written as

$$\frac{y}{a}=Z\left(1-\cos\frac{x}{l}\sqrt{\phi}\right)+C\sin\frac{x}{l}\sqrt{\phi}-\frac{\alpha\,x}{\phi\,l}. \quad . \quad . \quad . \quad (38)$$

Buckling Characteristics of different types of Strut.

Fig.		3	4	5
Bending line, type		C	C	S
End conditions	μ	∞	∞	$\frac{\pi}{2}$
	ν	5·71	6·63	$\frac{\pi}{2}$
	α	100	$\alpha=\phi$ = 30·23	$\alpha=\alpha_2$ = 12·9
Specific collapsing load	ϕ	30·23	30·23	15·21
Ratio of end moments	z	0·753	+ 1	− 1
Free buckling length	$\frac{\lambda}{l}$	0·571	0·571	0·805

Obtaining the value of C from equation (18), thus

$$C=\frac{Z\sqrt{\phi}}{\mu}+\frac{\alpha}{\phi\sqrt{\phi}}, \quad . \quad (39)$$

and substituting in equation (38), gives

$$\frac{y}{a\,Z}=1-\cos\frac{x}{l}\sqrt{\phi}+\frac{\sqrt{\phi}}{\mu}\sin\frac{x}{l}\sqrt{\phi}+k\left(\frac{\sin\frac{x}{l}\sqrt{\phi}}{\sqrt{\phi}}-\frac{x}{l}\right), \quad (40)$$

where $k=\frac{\alpha}{\phi\,Z}$. This last equation complies with the condition $y_0=0$, and with the end conditions required by equations (17) and (18); in order to satisfy the further condition stated by equation (19) the particular value of ϕ obtained from equation (27) has also to be substituted in equation (40).

In the case of the strut that is equally restrained at both ends, that is, $\mu=\nu$, equation (24) can be split into two expressions and (since $m=n$) can be re-written as

$$\phi\,m\,(m-2\operatorname{cosec}\sqrt{\phi})-\alpha\,m\left[m-2\left(\operatorname{cosec}\sqrt{\phi}-\frac{1}{\sqrt{\phi}}\right)\right]=0, \quad (41)$$

ELASTICALLY-SUPPORTED STRUTS.

Fig. 3. C-TYPE BENDING LINE FOR $\mu > \nu$.

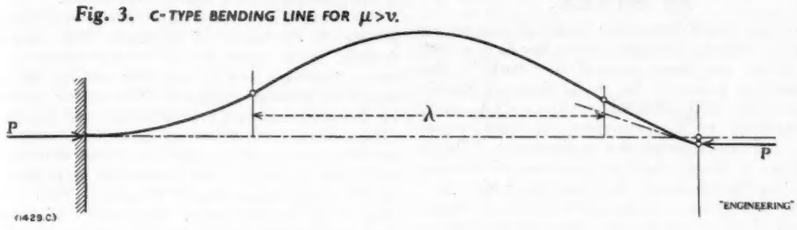


Fig. 4. C-TYPE BENDING LINE FOR $\mu > \nu$ AND $\alpha = \phi$.

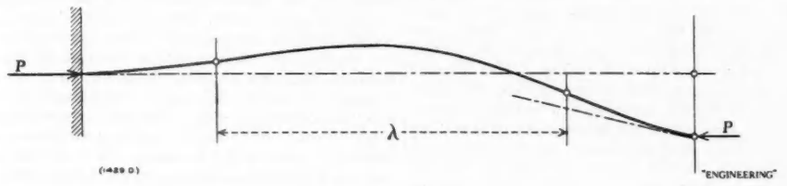
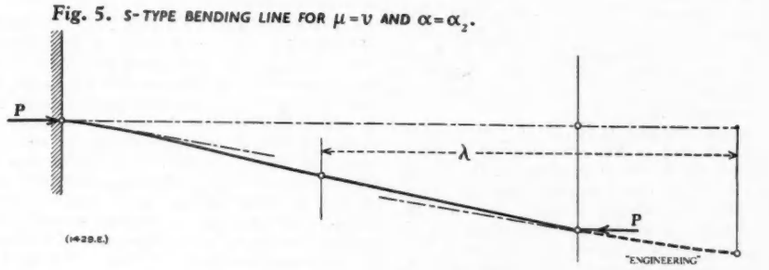


Fig. 5. S-TYPE BENDING LINE FOR $\mu = \nu$ AND $\alpha = \alpha_2$.



from which

$$\alpha = \phi \frac{m - 2\operatorname{cosec}\sqrt{\phi}}{m - 2\left(\operatorname{cosec}\sqrt{\phi} - \frac{1}{\sqrt{\phi}}\right)}, \quad (42)$$

which is satisfied identically for any value of α when $m = 0$. Consequently, the curve of ϕ plotted in terms of α degenerates into two distinct curves, namely: (*a*) a straight line, parallel to the α-axis, drawn at a value of ϕ that can be deduced from the following relationship, which has been obtained from equation (23) for the case of $m = 0$,

$$\sqrt{\phi}\cot\left(\frac{\sqrt{\phi}}{2}\right) = -\mu, \quad . \quad (43)$$

and (*b*) a curve that is described by the following equation,

$$\alpha = \phi \frac{\sqrt{\phi} - \mu\cot\left(\frac{\sqrt{\phi}}{2}\right)}{\sqrt{\phi} - \mu\left(\cot\left(\frac{\sqrt{\phi}}{2}\right) - \frac{2}{\sqrt{\phi}}\right)}, \quad (44)$$

which can also be obtained from equations (42) and (23); this latter curve meets the ϕ-axis at a point ϕ_0, such that

$$\sqrt{\phi_0}\tan\left(\frac{\sqrt{\phi_0}}{2}\right) = \mu. \quad . \quad (45)$$

These two curves intersect at $\alpha = \alpha_2$, thus increasing the significance of the special degree of fixing that was initially introduced to satisfy the case where $z = \infty$; as long as $\alpha > \alpha_2$, the specific collapsing load, ϕ, remains unaltered, despite increasing movability of the ends (provided that $\mu = \nu$), and equal to the specific collapsing load of the strut with its ends fixed in position. This is due to the fact that, in this case, the end of a column, carrying the critical load P, that is given a small displacement Δy will return to its initial position since the effective moment $P\,\Delta y$ is not sufficient to counterbalance the moment $-K_c\,\Delta y\,l$, to which, moreover, must be added the difference between the end moments. When $\mu = \nu$, then there is no opportunity for elastically unstable equilibrium in the case of an arbitrary lateral end shift, Δy, unless $\alpha < \alpha_2$, ϕ then decreasing with decreasing values of α.

THE PARTICULAR CASE OF A RIGID STRUT (EI = ∞).

In Euler's four formulæ there is no actual buckling load for a rigid stanchion. The type of strut, shown in Fig. 1, on page 67, under consideration in this article, however, has elastic end connections that can shift laterally and is liable to collapse under a certain load P′, without any previous buckling of the strut. The value of P′ can be deduced from equation (27) when $EI = \infty$, $p = q = 1$, and it is found, on writing the equation in terms of the coefficients $|K|$ rather than μ, ν and α, that

$$P' - \frac{K_a + K_b}{l} - K_c\,l = 0. \quad . \quad (46)$$

When $\mu = 0 = \nu$, it is found that this last equation agrees with equation (44) and this means that, if in the case of freely-hinged ends EI is so great that $\alpha < \alpha_2$ (giving an S-type bending line), then the system will collapse under a breakdown load of P′, instead of under a buckling load P.

EQUIVALENT BUCKLING LENGTHS.

The buckling of a strut under any end conditions can be found from Euler's formulæ if a suitable allowance for the end conditions is made by substituting an appropriately chosen effective length, λ, instead of the actual length, l, λ being chosen according to the following relationship deduced from a combination of equations (1) and (2),

$$P = \phi\frac{EI}{l^2} = \pi^2\frac{EI}{\lambda^2}. \quad . \quad (47)$$

In this way, each of the four Euler formulæ can be used to determine the equivalent length of a strut which, under ideal end conditions, has the same critical resistance to load as the strut under actual conditions of end connections as discussed in this article. That Euler's formula for the strut with freely-hinged ends fixed in position is commonly taken as the standard reference is probably due to its characteristic simplicity. From equation (47), it is possible to determine a relationship between the "free buckling length," λ, and the specific collapsing load, ϕ, thus

$$\lambda = \frac{\pi}{\sqrt{\phi}}l.$$

Furthermore, by differentiating equation (40) and equating the result to zero, it is found that

$$\sin\frac{x}{l}\sqrt{\phi} + \left(\frac{\sqrt{\phi}}{\mu} + \frac{\alpha}{Z\,\phi\sqrt{\phi}}\right)\cos\frac{x}{l}\sqrt{\phi} - \frac{\alpha}{Z\,\phi\sqrt{\phi}} = 0, \quad (48)$$

and differentiating again gives

$$\frac{x}{l}\sqrt{\phi} = \cot\left(\frac{\sqrt{\phi}}{\mu} + \frac{\alpha}{Z\,\phi\sqrt{\phi}}\right). \quad (49)$$

This is the equation for the abscisse, x_1, x_2, . . . of the points of contraflexure of the bending line. If this last equation is satisfied by the least value of x, x_1, then, in addition, it is satisfied by a value x_2, for which

$$x_2\frac{\sqrt{\phi}}{l} = x_1\frac{\sqrt{\phi}}{l} + \pi,$$

π being the period of the cotangent function. It follows, therefore, that

$$x_2 - x_1 = \frac{\pi}{\sqrt{\phi}}l, \quad . \quad . \quad (50)$$

that is, the free buckling length is equal to the distance between the points of contraflexure. Similarly, referring to Euler's formula for rigidly-fixed ends, it is found that the equivalent buckling length is

$$\lambda_1 = \frac{2\pi}{\sqrt{\phi}}l. \quad . \quad . \quad (51)$$

Since equation (48) is to be used to determine the abscisse, x_a, x_b, x_c . . . of the points of zero slope of the bending line, and since both sine and cosine functions have a period of 2π,

$$x_c\frac{\sqrt{\phi}}{l} = x_a\frac{\sqrt{\phi}}{l} + 2\pi.$$

Therefore,

$$x_c - x_a = \frac{2\pi}{\sqrt{\phi}}l,$$

that is, for a given buckling load, the length of the Euler strut with rigidly-fixed ends is equal to the distance between the first and third points of zero slope of the strut with practical end conditions, as described in this article. Since x_a, x_c generally lie on extensions of the theoretical bending line, and, therefore, beyond the ends of the strut, this result is only of minor practical interest.

Next, consider the results of the arguments set out in this article when compared with Euler's formulæ for a strut rigidly fixed at one end, the other being either pinned or free. For this comparison, there should be a simple geometrical relationship between the effective buckling length,

$$\lambda_2 = \frac{\pi}{2\sqrt{\phi}}l \quad \text{or} \quad \frac{\sqrt{2{\cdot}04}\,\pi}{\sqrt{\phi}}l, \quad (52)$$

and the distances between the point of zero slope, x_a, and points of contraflexure x_1 or x_2, but it is found by similar considerations to those used previously that

$$x_1 \text{ or } x_2 - x_a = \left(\frac{\pi}{2} \text{ or } \frac{3\pi}{2} - \kappa\right)\frac{l}{\sqrt{\phi}} = \left[\left(1 - \frac{2\kappa}{\pi}\right) \text{ or } \left(1{\cdot}049 - \frac{0{\cdot}7\,\kappa}{\pi}\right)\right]\lambda_2,$$

where κ is given by $\tan\kappa = \dfrac{B + \tan\psi}{1 - B\tan\psi}$ in which $\psi = \dfrac{x_a}{l}\sqrt{\phi}$ and $B = \dfrac{\sqrt{\phi}}{\mu} + \dfrac{\alpha}{Z\,\phi\sqrt{\phi}}$. That the

rule enunciated in equation (50), which is known to hold for ideal end conditions and to this extent is dealt with in textbooks, should be valid in any case is not at all self-evident: the collapsing load for the whole strut must be equal to that determined for the part of the strut between the points of contraflexure, this part being considered as a strut with freely-hinged ends. At first sight, it may seem surprising that the critical load of this part should be given by $P = \pi^2 \frac{E I}{l^2}$ (as for Euler's strut with freely-hinged ends that are fixed in position) whereas, in general, there must be a relative lateral movement, Δy, of the points of contraflexure. Due to this movement, a proportional shearing force must be generated, equal to $K_f \Delta y$ and corresponding to a degree of lateral fixture α_f for the effective strut length, λ. Conditions of equilibrium between the points of contraflexure require that $P \Delta y = K_f \Delta y \lambda$; multiplying throughout this equation by $\frac{\lambda^2}{E I}$ shows that it reduces to $\phi = \alpha_f$. On the other hand, for the part of the strut between the points of contraflexure, $\mu = \nu = 0$ and $\phi = \pi$; substituting $\phi = \pi$ in equation (37) gives $\alpha_2 = \pi = \phi$ and, consequently, $\alpha_f = \alpha_2$. For this particular degree of lateral fixture the buckling load is still, as deduced above, the same as that determined in the case of $\alpha = \infty$. It follows, therefore, that, for the part length, λ, of the strut between the points of contraflexure, the Euler formula $P = \pi^2 \frac{E I}{\lambda^2}$ still remains valid although it was devised for the case of a strut with its ends fixed in position. The unrestricted validity of equation (50) is explained by the fact that the part of the strut between the points of contraflexure behaves like a strut with freely-hinged ends but with the "special degree of lateral fixity" defined in this article. In the case of S-type bending, the part of the strut between the points of contraflexure of the bending line, as given by equation (40), extends beyond the ends of the struts; even then (these "parts of the strut" not representing any material part of the strut), the theorem contained in equation (50) remains valid.

INSTITUTION OF ELECTRICAL ENGINEERS PREMIUMS.—The Council of the Institution of Electrical Engineers has awarded the following premiums for papers read or accepted for publication during the 1952-53 session: Kelvin premium, Dr. W. Culshaw; John Hopkinson premium, Mr. D. McDonald; Llewellyn B. Atkinson premium, Messrs. O. J. Crompton and G. A. Wallace; Silvanus Thompson premium, Mr. P. S. T. Buckersfield; Mather premium, Messrs. L. Hartshorn, J. V. L. Parry and E. Rushton; Duddell premium, Mr. D. C. Birkinshaw; Ambrose Fleming premium, Mr. D. A. Wright; Frank Gill premium, Messrs. L. B. S. Golds and P. Schiller; Heaviside premium, Mr. R. H. Barker; Paris Exhibition (1881) premium, Messrs. C. A. Cameron Brown and P. G. Finn-Kelcey; and Webber premium, Messrs. G. W. A. Dummer and D. L. Johnston. A number of Extra and Students premiums were also awarded.

POWER FACTOR METER.—The General Electric Co., Ltd., Kingsway, London, W.C.2, have introduced a meter for testing power factor; it comprises a link unit and plug-in indicator. The link unit has a hinged pole piece so that it can be placed in position round a current-carrying conductor without breaking the circuit and has sockets in the handle into which leads from the indicator can be plugged. The indicator has two 2½-in. scales with ranges from 50 to 100 amperes and 100 to 250 amperes, respectively, and from 0·5 lagging to 0·5 leading power factor. It is a single-phase power-factor instrument of the moving-iron type with a split-phase circuit and can be used to measure power factor in both single and polyphase circuits, provided the neutral is available and the phase voltage does not exceed 250 volts. When no neutral is available on delta-connected circuits, a lead incorporating an artificial neutral point resistance can be used in place of the standard lead, while an external resistance is available to enable the instrument to be employed on voltages up to 600 volts.

BRITTLE FRACTURE IN STEEL.

"WHEN the Schenectady broke in two at her pier at Portland, Oregon, one wintry day in 1943, the shock was heard around the world." This remark was made by Dr. S. L. Hoyt, of Battelle Memorial Institute, Columbus, Ohio, U.S.A., in his contribution to a symposium of eight papers presented for discussion at a conference on "Brittle Fracture in Steel," held at the West of Scotland Iron and Steel Institute, in Glasgow, on May 15.

The Schenectady was a newly-built all-welded oil tanker, which broke in two for no apparent reason while moored at the builder's fitting-out quay on the evening of the day on which she successfully passed her acceptance trials. This event gave rise to one of the largest research efforts ever devoted to a single problem, both in the United States and in the United Kingdom. This research effort, which was at first directed towards the elucidation of the special problems of stress distributions in welded structures, has latterly been focused on the property of steel known as "notch brittleness," and the keen interest in this problem is reflected in the large attendance—over 100 people—at the Glasgow conference. The eight papers were briefly introduced in two groups of four by the *rapporteurs*, Mr. W. Barr (Colvilles, Limited) and Dr. H. Harris (Babcock and Wilcox, Limited), who emphasised the salient points in order to stimulate and focus the discussion.

The paper presented by Mr. Hoyt, who has taken a prominent part in the investigations, reviewed the studies which are in progress in the United States. In a historical introduction, the paper showed that the liability of mild steel to brittle fracture at low temperatures was known as long ago as 1864, but serious attention was first drawn to it by the spectacular failure of the Schenectady, and particularly by the report of Professor S. H. Graf, who first investigated the case. His observations that the steel was notch-brittle when tested at the temperature at which the failure occurred, together with subsequent investigations on this and other similar cases, had marked an epoch in engineering circles in the United States. In subsequent investigations it was realised that any tests on the steel should reproduce the stress conditions of the actual failure. The paper dealt mainly with the investigations on notch-brittleness of steel; nevertheless, the author stated his view that the proper remedy, barring faulty workmanship and inspection, might be a modification of design to produce a better streamline flow of stress, or to relieve the rigidity, or to provide means for arresting any fractures that might develop. The importance of a better understanding of the mechanics of fracture was emphasised, and the need to establish a truly representative test to reveal the relevant properties was brought out in a lucid discussion of the basic questions involved. In discussing some of the many tests that had been suggested, the author recalled some Charpy tests, in which the standard size of notched-bar specimen failed to discriminate between a good and a poor steel, whereas a double-width specimen revealed a marked difference. This case showed the necessity for studying the geometrical effects in testing, and the desirability of testing not only the steels which had failed, but also those which had sustained similar service without failure.

The author suggested that steels should be compared on the basis of a concept which he called the "Match Point," i.e., the combination of stress distribution and temperature which just produced rupture at the elastic limit, without plastic deformation. The studies on rate of straining were reviewed, and it was shown that high rates of loading do not necessarily produce brittle fracture. Known cases of ductile fractures in steel plates struck by high-velocity projectiles were cited in illustration of this remark. The paper went on to review the studies on steelmaking variables such as composition, deoxidation, heat treatment, etc., and to describe the practical measures which have been taken by the American Bureau of Shipping in recent amendments to its rules. The investigations on material taken from fractured ships at the National Bureau of Standards, the U.S. Naval Research Laboratories, and other establishments were referred to, and some of the more important results were stated.

The point of view of the shipbuilder was presented by Mr. N. G. Leide, of Kockums Mek, Malmo, Sweden, in a paper giving several instances of service fractures and of remedies adopted in this important Swedish shipyard. The author pointed out that the problem of brittle fracture had increased in importance with the wider adoption of welding, but that it was not peculiar to welded structures. Of fifteen major structural failures in ships during the five-year period ended February, 1952, four occurred in riveted ships. The causes of brittle fracture and methods for revealing the tendency to it by laboratory tests were discussed. The author favoured the Schnadt test, and gave criteria, based on actual tests, whereby steel of adequate toughness could be selected. It was concluded that the shipbuilder could minimise the risk of brittle fracture, although its causes were not fully understood, by careful attention to workmanship, the adoption of designs which obviated stress concentrations, and by the use of specially tough steel at vulnerable parts of the structure. It was, however, the job of the steelmaker to produce tough material at a reasonable price.

Another Swedish contributor, Mr. P. Matton-Sjöberg, of Domnarfvets Jernverk, in a paper on "The Mechanisms of Fracture in Impact Tests," described a series of tests on mild steel using standard Charpy keyhole and Schnadt impact tests, in which the process of fracture formation was studied in detail by means of special techniques developed for the purpose. The results were carefully correlated with the compositions and metallurgical structure of the steels considered. The studies were conducted at various controlled temperatures to reveal the mechanisms of fracture in both the ductile and brittle states. It was found that, in the ductile state, even with the sharpest possible notches, there was a tendency for fissures to form in the direction of the ferrite bands, with the result that the notched bend specimens split up into a series of small tensile specimens, which eventually parted after considerable deformation and "necking." Laminar slag inclusions in the steel had a similar effect to that of banding, i.e., to increase the toughness. An instance was given of two plates rolled from the same ingot, one of which was treated to produce a banded structure, while the other was treated to minimise banding, without marked differences in grain size. The banded plate showed lower energy absorption in the ductile range, but ductility was maintained to much lower temperatures than in the other plate. This result was confirmed by two very different types of test, i.e., the Charpy V-notch impact, and the Tipper slow notched tensile test. The micro-mechanisms of fracture were studied, and some excellent photographs at high magnifications were given in the paper. The fundamentals of brittle fracture were discussed, and it was concluded that, as regards risk of such fracture, steels might best be judged by comparing their transition temperatures, defined as the highest temperature at which the fracture is brittle. The actual energy absorptions in the ductile range was not considered significant.

A statistical investigation of the effects of plate thickness and production variables on the V-notch Charpy transition temperature of ship-quality plate was given in a paper by Mr. I. M. Mackenzie, of Colvilles, Limited. For this purpose, the "transition temperature" was defined as the temperature at which the Charpy V-notch impact value is 15 ft.-lb. The specimen material was taken from the current production of two Scottish steelworks, in which slightly different rolling practices were used. The paper gave a mass of data regarding the specimen material and on the test results, presented in tabular and graphical form, and the results were fully discussed. It was shown that the inferior notch ductility of thick plates was accounted for by the lower rate of cooling and higher finishing temperatures—factors which influenced the metallurgical structure of the steel. It was concluded that the variance of notch ductility in ship-quality steel produced at the two mills arose because of variation of plate thickness, finishing

temperature and the content of manganese, nickel and phosphorus. It was suggested that there were at present only three measures that could be applied to improve the notch ductility of plates. These were increasing the Mn : C ratio, normalising, and deoxidising with aluminium. These could be applied either singly or in combination, but since their adoption increased the cost of producing the steel, it was necessary to consider, firstly, whether an improvement in notch ductility in either thick or thin plates was essential; secondly, the degree to which it was economic to improve the notch ductility; and, thirdly, which measures would produce the desired improvements at the lowest cost. The author stated the view that many successful welded structures had been built using steel in every way similar to that studied in the paper, and that the present problem had arisen because of the progressive increase in the thickness of the plates used.

Mr. T. S. Robertson, M.Sc., who has developed a novel test for notch ductility, described in ENGINEERING, vol. 172, page 445 (1951), and his colleague, Mr. D. le M. Hunt, B.Sc., both of the Naval Construction Research Establishment, Dunfermline, gave a joint paper describing an interesting development of the Robertson test. The specimens were prepared in such a way that the deflections after fracturing could be measured, together with the forces required just to maintain fracture propagation. The investigations led to the surprising conclusion that the force required for propagation at a given temperature and for a given material was constant whatever the length of crack. This was an experimental conclusion which only emerged in the analysis of the test results. The significance of this finding seemed to be that no matter how long the crack is, a certain critical shear force, perpendicular to the fracture surface, is required to maintain propagation. This peak force was not affected by the length of uncracked material ahead of the propagating crack, provided that this was sufficient to prevent end effects. The measurement of this critical force enabled the surface energy, i.e., the work done in propagating the fracture, to be calculated, and the results of such calculations were given in the paper.

Professor Ir W. Soete, of the University of Ghent, Belgium, gave a paper describing notched bend tests, in which it was found that in so-called shear fractures, fissures tended to form in the plane of the plate, perpendicular to the main fracture, in the manner found by Mr. Matton-Sjöberg. The presence of these fissures explained the macroscopical difference between brittle and shear fractures, and their effect was to modify the state of stress from triaxiality to biaxiality. They might also explain the abrupt change in ductility observed at the transition temperature, without significant alteration in the fracture strength. This observation focused attention on the importance of the strength of plates in the thickness direction as a factor in determining the transition temperature, and the author suggested that the determination of this transverse strength, and its relation to temperature, would be a valuable and simple index of notch ductility. A low transverse strength would favour ductility, but it should not be allowed to fall below a certain minimum for other reasons.

The important problem of the effects of dimensions in testing was studied in a paper by Mrs. C. F. Tipper, M.A., Sc.D., D.Sc., of Cambridge University Engineering Department, who reviewed the evidence on many vexed questions related to size effect and notch geometry. The previous work was reviewed, and some hitherto unpublished experiments carried out by the author were described. It was shown that much of the previous work had been rendered difficult to interpret owing to the intrinsic difficulties in ensuring metallurgical identity in specimens of different sizes. Even the classical experiments of Docherty on notched bend specimens of varying dimensions were said to be open to some doubt about the metallurgical similarity of his material. In these experiments the energy to fracture was found to diminish with increase in size, but this was chiefly due to changes in the character of the fractures, the energy to maximum load generally remaining constant. Where there was no change in fracture, as for example in bronze, the dimensional effect was negligible. The author concluded that the higher transition temperatures of thick plates were of metallurgical origin; that dimensions were relatively unimportant except in the presence of a notch, in which case they determined the conditions under which fractures were initiated and propagated; and that many of the inconsistencies in test results, particularly in the determinations of transition temperatures, could be attributed to the undue influence of the initiating notch. The paper concluded with a quotation from E. R. Parker: "It appears that the size effect in fracture is dependent not upon size as such, but only upon the local condition of stress and strain at geometrical discontinuities, which may vary markedly in similar specimens of different sizes."

"The Influence of Welding on Notch-Brittle Fracture" was the title of the paper presented by Dr. A. A. Wells, of the British Welding Research Association, in which evidence was produced to show that many of the brittle fractures which originated from welds were initiated by the strain-hardening which took place as a result of the plastic flow caused by the heat-cycle of welding. The stored elastic strain energy associated with the residual stresses induced by this plastic flow provided the necessary energy to initiate fracture. The propagation of fractures was also studied, making use of an adaptation of Griffiths' theory to take account of the plastic properties of steel, in the manner suggested by Irwin and Orowan. The author had developed a method for measuring the surface energy of brittle fractures by means of the heat-wave produced by the transit of the fracture past thermocouple stations. The author believed that, apart from the adoption of steel with a low transition temperature, there were at least two remedial measures that could be used, i.e., to eliminate metallurgical and geometrical notches as far as possible, and to minimise the stored elastic energy arising from residual stresses. An interesting diagram was given to summarise the degrees of safety at varying temperatures which might be inferred from the transition curves for steel according to various types of test, and formulæ were given for the minimum length of crack necessary to propagate fracture.

DISCUSSION.

Opening the discussion, Mr. G. M. Boyd (Lloyd's Register of Shipping) congratulated the organisers on the excellence of the papers. The symposium, he said, had two outstanding features, i.e., the recognition that the properties of the parent steel were important, and the realisation that the mechanics of fracture required further study. He could not fully visualise Dr. Hoyt's concept of "Match Point," and personally preferred energy concepts, which could, if desired, be analysed. Referring to Mr. Leide's paper, he said Lloyd's Register of Shipping Rule P. 403, was applied having regard to impact values and many other factors besides composition. Mr. Matton-Sjöberg's paper was important in that it brought the brittle and ductile states into focus, and showed the futility of relying on purely stress concepts. Mr. Mackenzie's paper had shown that the rate of cooling was an extremely important factor which seemed to warrant further study by the steelmakers. The ingenious method for deriving surface energy suggested by Robertson and Hunt showed promise and was an interesting confirmation of his own theoretical conclusions.* Professor Soete's work agreed well with that of Mr. Matton-Sjöberg in showing the importance of texture as distinct from composition. Dr. Tipper's paper admitted two important conclusions, i.e., that increasing width made the transition range more definite, and that the differences in transition temperatures which accompanied changes in thickness were mainly of metallurgical origin. Regarding Dr. Wells' paper, he felt that the adaptation of Griffiths' theory to plastic materials should be done with caution, since the underlying assumptions were severely affected by the intervention of plasticity. He thought also that, besides strain hardening, strain ageing was an important factor in the initiation of fractures from welds. Dr. Wells' method for measuring the surface energy was an important contribution which showed great promise.

Mr. A. H. Sully (Fulmer Research Institute) referred to the importance of hydrogen as a factor in promoting initiation and propagation of fractures. The atomic hydrogen in the steel tended to diffuse out to form pockets filled with molecular hydrogen at high pressure, which could act as nuclei for fracture initiation. He described experiments on specimens held at constant stress, some of which were treated with hydrogen and others not. Of the untreated specimens, 75 per cent. broke within one and 240 hours from loading, with an average of 100 hours. Of the treated specimens, 70 per cent. broke in less than one hour. He referred to other recent work on delayed fracture, and thought this phenomenon worthy of further study.

Dr. B. B. Hundy (British Iron and Steel Research Association) referred to Dr. Wells' use of Orowan's adaptation of Griffiths's theory, and doubted its validity for plastic materials. Some analyses of the stress distributions in the Charpy V-notch test had been made by A. P. Green for B.I.S.R.A., and these showed that in the middle of the region below the notch there was a cylindrical portion of material which remained un-deformed up to an advanced stage in the bending. He considered that little, if any, strain ageing took place during the test.

Mr. B. E. Hopkins (National Physical Laboratory, Metallurgy Division) said that the effects of rate of loading (or straining) on the transition temperature were quite small, and varied from one steel to another. He thought sufficient attention had not been paid to the possibility of fracturing at grain boundaries, as distinct from cleavage. The work on iron-carbon alloys at the N.P.L. had shown a sharp rise in transition temperature in the first stages of the appearance of grain-boundary failure. This work had also shown that microcracks in the carbide, mentioned by Mr. Matton-Sjöberg, could start cleavage fractures in the ferrite. This was found to have an important effect on the shape of the transition curve. Heat treatment not only affected the grain size, but also had other, perhaps more important, effects.

Dr. K. Winterton (British Welding Research Association) referred to Dr. Hoyt's experiments on double-width specimens and remarked that the type of fracture could not always be predicted from the specimen geometry, even in a given material. He remembered a case of an Izod specimen having three notches in different faces, in which the fracture was brittle in two notches and ductile in the other. The whole subject seemed to be very confused and full of anomalies. He asked whether Mr. Mackenzie could give some information on the economics of the development of tougher steels.

Mr. A. J. K. Honeyman (Steel Company of Wales) said that a great "dust cloud," consisting of a spate of papers, discussions and tests, as well as "tests of tests," had been raised by the spectacular fracture of the Schenectady in 1943. Whenever this dust cloud began to settle, someone stirred it up again. Ideas had changed greatly since then, and we were now getting down to considering calmly what the steelmaker, the engineer, and the designer, respectively, could do about it. He thought it important to separate the fundamental and theoretical aspects from the practical aspects. From the practical point of view, it would be preferable for engineers to specify composition and heat treatment rather than impact tests. The designer or engineer should decide which type of steel he required, bearing in mind that notch toughness could be bought but must be paid for. He felt that the true remedy lay with the designers, and cited Dr. Hoyt's remark that "the proper remedy, barring faulty workmanship or inspection, may be a modification of design to produce a better streamline flow of stress; or it might be the use of some device to relieve rigidity and to arrest any fractures that might start."

Dr. M. L. Becker (B.I.S.R.A.) referred to the passage in Mr. Matton-Sjöberg's paper: "There is, evidently, only one condition which must be satisfied for the initiating and propagation of a brittle fracture: the stress system, determined mainly by

* See ENGINEERING, vol. 175, pages 65 and 100 (1953).

geometry, loading rate and temperature, must be of such an intensity that normal stresses greater than the critical stresses are obtained on the cleavage planes of the ferrite." This overlooked the possibility of fracture at grain boundaries. He thought this aspect should be further considered, and a distinction should be drawn between ferritic and austenitic grain structures. He thought Mr. Mackenzie's paper had shown the importance of controlling rolling temperatures, and asked whether the steelmakers could not devise some method for rolling plates in two stages, with a cooling interval between them. They might also try other methods of controlled rolling, and perhaps artificial quenching with water or air.

Dr. J. H. van der Veen (Royal Netherlands Blast Furnaces and Steelworks) referred to Dr. Becker's remarks, and said that controlled rolling was a feasible and practical proposition, at least in the works with which he was connected, and it was in fact being used to produce steel to Lloyd's Rule P. 403. With regard to Mr. Matton-Sjöberg's statement that different tests placed steels in the same order of merit, he said this was only roughly true. It depended on the criterion adopted. He sketched load-deflection diagrams for notch-bend tests on two steels, showing one to be much better than the other on the basis of energy absorption but that the reverse was the case on the basis of fracture appearance. In reply to a question by Mr. Boyd, he said he personally preferred fracture appearance as a criterion, but the choice was not a straightforward one, and depended on the steel. He thought that the Robertson test might be useful in helping to decide the vexed question of criteria. In general, increasing the manganese/carbon ratio tended to improve steels according to energy criteria, whereas controlled rolling improved them with regard to the fracture appearance criterion.

Mr. W. Barr (Colvilles, Limited) said there was much controversy on the subject of criteria; it had been fully discussed in the International Institute of Welding Commission on Brittle Fracture. An interchange of specimens had been arranged between Sweden, Holland, Belgium and the United Kingdom, with the object of comparing various types of tests and criteria. On the question of controlled rolling, he said, this had been and was being studied carefully, but there were serious economic difficulties, depending on the facilities in different steelworks. It was practical at the Royal Netherlands steelworks because of the peculiar layout of their plant. He thought Dr. Becker's suggestion would be economically impossible.

Mr. N. G. Leide (Kockums Mek., Sweden) said that British shipbuilders were fortunate in having suffered very little from brittle fracture, and this was a great credit to the British steelmakers. British steel was, however, difficult to obtain on the Continent. He thought that the principle of "streamlining" the stress, referred to by Dr. Hoyt, Mr. Honeyman and in Mr. Barr's introduction, could only be carried so far, and was really an unattainable ideal. It was necessary to go on improving the properties of the steel. The analysis, heat treatment, etc., meant little to the shipbuilder, who was only concerned with physical properties and performance. He thought low carbon was more important than high manganese, and asked whether the steelmaker's "extra" for using the Robertson test would be more or less than that for the Charpy impact test.

Mr. A. M. Sage, B.Sc. (B.I.S.R.A.) said his Association had long realised the importance of the notch brittleness problem, and had set up a notch ductility survey *ad hoc* committee. With the collaboration of the British steelmakers, a survey of the notch ductility of steel from current production had been made. He was not in a position to give details of the results, but hoped they might be published at the Iron and Steel Institute meetings in Sweden next year. The survey had shown considerable variations in notch ductility with thickness, the thicker plates being less ductile. There were also considerable differences as between steelmakers, and the reasons for these were being investigated. A study was being made of the effects of rolling practices, and the susceptibility to strain-ageing was being studied at Sheffield. Studies were also being made on the variations due to different methods of forming the notches in Charpy impact specimens. He referred to a recent paper by B. C. Woodfine on temper brittleness (*Jl. I. & S.I.*, March, 1953, page 240) in which a theory of the impact test was given.

Dr. R. Weck (Cambridge University) said it was important that someone should study the papers to find what common ground there was among them. They showed remarkable differences in approach, but since they all dealt with the same problem there should be a common thread running through them. He asked what Mr. Matton-Sjöberg meant when he said the Schnadt specimen behaved as a "monopiece beam," and asked Mr. Robertson for further explanations of the method of extrapolation he had adopted. With regard to Dr. Wells' conclusion that strain hardening was the only mechanism by which fractures were initiated from welds, he said it was impossible to eliminate strain-hardening entirely, as it was inseparable from all fabricating processes. In the case of welding, the strain-hardening of the parent material was not by extension, but by compression, or upsetting. He wondered whether the treatment known as "low-temperature stress relief," which was in reality a mechanical stretching of the material, would not produce the very conditions which Dr. Wells considered so dangerous.

Mr. J. W. Strawson (Shell Refineries) said he had been recommended to use "boiler-quality" steel at an "extra" of 50*s.* per ton, and asked whether this would be a safeguard against brittle fracture. It was very puzzling from an engineer's point of view. For example, he had recently ordered some steel with a high manganese/carbon ratio, normalised, but it showed poor impact properties. He wondered whether the steel obtainable to-day was so good as it was some years ago, and whether there had been any deterioration in the notch ductility. He was interested in Dr. Wells's paper, and would like to know more about the "critical crack length."

Mr. T. D. Pearson, M.Sc. (Consett Iron Company) said the problem had long been known to steelmakers, and had been solved at the practical level. The steelmakers could supply material having any desired properties, but notch ductility had to be paid for like any other special property. He took issue with Mr. van der Veen on the matter of his choice of fracture appearance as the best criterion. This depended on the inspector and on how he was feeling at the time, and was therefore open to human error. Referring to the advantages of a banded structure, he said this was promoted by phosphorus, which might therefore be beneficial.

Mr. A. H. Goodger (National Boiler and General Insurance Company) said the papers were the best set he had yet seen. He asked why brittle failure did not always result from potential initiators such as weld defects. Such defects could not be entirely avoided, and some were found by X-ray methods in welds that would be regarded as sound. He had heard of a ship, known to have cracks, going all over the world, and even through tornadoes, without complete failure. He was interested by the mention of "delayed" and "spontaneous" fractures, and by the known fact that brittle fractures sometimes occurred in steel having a high impact value. Recently, during the water testing of a large storage tank, when the water had reached about 38 ft., a vertical crack about 19 in. long occurred across the first circumferential weld. This crack did not propagate further, so the tank was emptied and the crack welded up. Later, when the water had reached about 48 ft., the tank split from top to bottom, and it was found that the fracture had not started from the original crack, but from a much smaller defect. He had a theory that an internal notch, near the edge of a plate, was more dangerous than an open notch at the edge. He demonstrated this with paper to show that with an open notch considerably more effort was needed to break the paper than with a small hole near the edge. Dr. R. Weck (Cambridge University) intervened to say he thought there was something in Mr. Goodger's theory. His studies on fatigue showed that there was a greater concentration of stress at an internal notch near the edge than in an open notch.

Dr. Wells said he had tried Mr. Goodger's trick with steel. He had made three specimens: one with a central internal notch; one with a similar notch near the edge, and the third with an open notch on the edge. The breaking loads were 6·0, 4·5 and 0·88 tons, respectively, which did not agree with Mr. Goodger's surmise. Mr. Boyd intervened and referred to Mr. Goodger's question as to why catastrophic failure did not always result from all defects. He thought it was a matter of compound probabilities. For a catastrophic failure to occur, several conditions had to be fulfilled simultaneously, e.g., a notch at a vulnerable point, a sufficient stress level, low temperature, brittle steel, etc. The individual probabilities for each of these circumstances might be quite high, but the probability of their simultaneous occurrence might be very small.

Mr. Robertson said it was necessary to go on investigating the problem from all its aspects. One should not accept it as inevitable that ferritic materials were subject to notch brittleness, but should seek remedies for it. Notches could not be entirely avoided by design, and could occur accidentally in use. He was not fond of energy as a criterion, since it was compounded of stress and strain, while engineers could only determine stresses. There was always plenty of energy to propagate fractures unless the stress was low. He thought the necessary elastic energy for propagation was derived from a relatively small zone in the vicinity of the fracture. Regarding Dr. Tipper's doubts as to the metallurgical similarity of Docherty's specimens, he had been associated with these experiments, and could vouch for the care that was taken to ensure metallurgical uniformity throughout. He was continuing his experiments on the "cracking test," and was finding out some interesting things. He was starting the cracks with a single blow from a pneumatic hammer, in which the pressure could be varied, and was correlating the pressure with the crack length.

Mr. D. le M. Hunt (Admiralty Naval Construction Research Establishment) said the available elastic energy was only important in that it should be sufficient to maintain the conditions for propagation. The total elastic energy was irrelevant if it was over a certain amount. He referred to Mr. Boyd's recent paper in ENGINEERING, and said the "borders" or "shear lips" seemed to absorb considerable energy, and might have an important influence on the actual and apparent velocities of propagation.

Mr. G. N. J. Gilbert said that much of the work that had been done on nodular cast iron was relevant to the problem under discussion, and recommended that it should be studied. He described impact tests using V and keyhole notches, as well as tensile tests on un-notched specimens, which showed transitions in both fracture appearance and in energy absorption.

Dr. C. F. Tipper referred to Mr. Hopkins' remarks which had been endorsed by Dr. Becker. She said that none of the service fractures had been intercrystalline, and she doubted whether fracture at grain boundaries was a factor in the ship failures. She had been impressed by the large measure of agreement which had now been reached on points which had been highly controversial in the past. On the matter of "available energy," she agreed that the necessary elastic energy was probably derived from the vicinity of the fracture. The total energy probably controlled the extent, but not the character, of the fracture. She proposed to amplify her comments in a written contribution.

Mr. Mackenzie said his paper was a co-operative effort, and acknowledged the help of his colleagues in preparing it. He thought that the effect of killing was to produce a fine-grain structure which was conducive to toughness. Manganese was beneficial in its own right, and not only as a means for reducing the carbon. Referring to Mr. Pearson's remark, phosphorus did not entirely explain banding, which could result from other causes. There were cases in which engineers were justified in requiring an impact test, but the extra cost of this would preclude its indiscriminate use. Notwithstanding Mr. Strawson's remark, he thought that steel was generally better to-day than in the past. Initiation and propagation were distinct and

EXHIBITS AT THE PARIS AIR SALON.

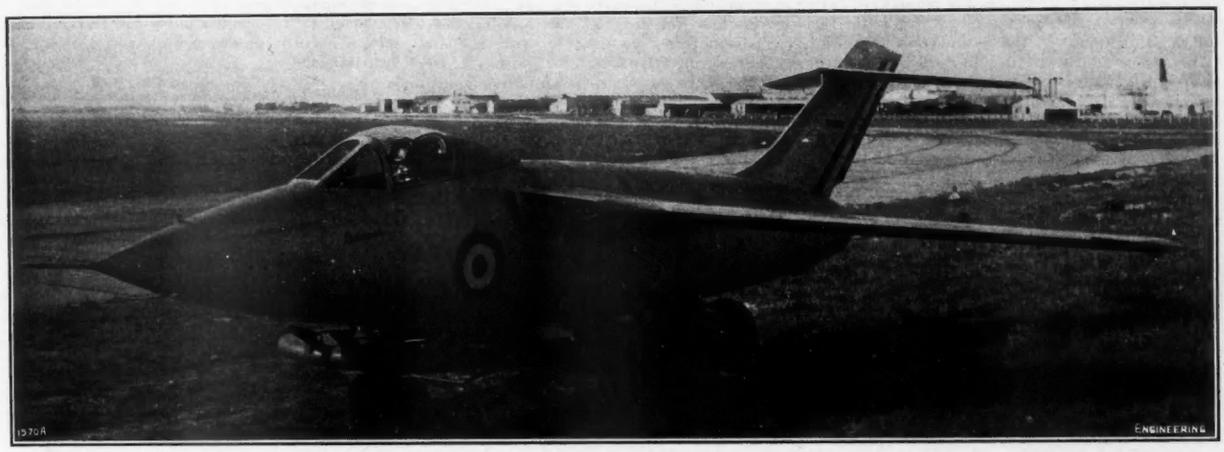


FIG. 5. "SE 5000 BAROUDEUR" GROUND-SUPPORT AIRCRAFT.

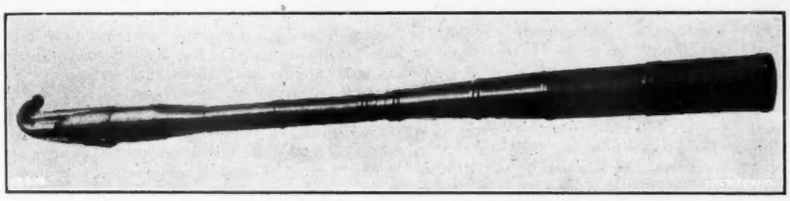


FIG. 6. S.N.E.C.M.A. "ESCOPETTE" PULSE JET.

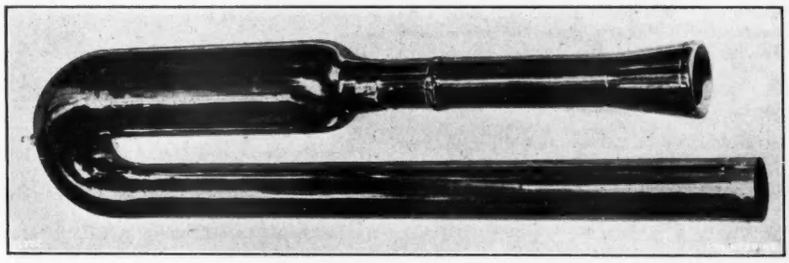


FIG. 7. S.N.E.C.M.A. "ÉCREVISSE" PULSE JET.

separate phenomena which could be catered for by different steelmaking practices.

Dr. Wells, alluding to Mr. Strawson's remark, quoted from a book by Kirkaldy, dated 1861, in which it was lamented that steel and iron were "not what they used to be." Referring to Mr. Boyd's remark on strain-ageing, he agreed that this was a factor. It raised the transition temperature but did not affect the residual stress, which he considered essential for initiation of fracture. He mentioned a recent case of a large container which had been subject to "hot spots" on the shell These caused local strain-ageing and residual stress, which led to a serious brittle fracture. On Dr. Weck's remark regarding the strain-hardening due to shearing, flanging, etc., he agreed that this was conducive to fracture, but a notch was essential, and if there were no notch, fracture would not commence. He had made some calculations which tended to confirm Mr. Boyd's assumption of a constant rate of energy release in fracturing.

The chairman, Professor R. Hay, B.Sc., Ph.D., then closed the discussion, which he said had been most lively and productive. He had been impressed by the wide variety of points of view, and by the number of anomalies and divergencies of opinion on material points, in spite of Dr. Tipper's remark to the effect that the position was better in this respect than formerly. The problem obviously called for a great deal of sorting out and clarification, and he felt sure that the symposium would stimulate thought on these lines. He thanked the authors, *rapporteurs*, and contributors to the discussion, and congratulated the organisers on a successful meeting.

A full report of the conference, including the papers, is to be published by the West of Scotland Iron and Steel Institute, 39, Elmbank-crescent, Glasgow, C.2.

COUNCIL OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—Mr. H. Bishop has been elected President of the Institution of Electrical Engineers for the 1953-54 session. The new vice-presidents are Mr. S. E. Goodall and Sir George Nelson, and the new members of council Professor Willis Jackson and Mr. A. T. Crawford, Mr. G. S. C. Lucas, Mr. R. L. Smith-Rose, Mr. G. O. Watson, and Mr. R. T. B. Wynn. The honorary treasurer is Mr. H. W. Grimmitt. The new chairmen of the specialised sections are: Mr. J. F. Coales (Measurements); Mr. J. A. Smale (Radio); Dr. L. G. Brazier (Supply); and Mr. B. L. Metcalf (Utilisation).

25-KW RADIO-FREQUENCY EDGE-GLUING MACHINE.—On page 633 of our 172nd volume (1951) we described a 5-kW radio-frequency edge-gluing machine which had been developed jointly by Messrs. Fielding and Platt, Ltd., Gloucester, and the General Electric Co., Ltd., Kingsway, London, W.C.2, for manufacturing blockboard and similar products. The same firms have now made a 25-kW model for the production of boards from 36 in. to 80 in. long, up to 40 in wide and with a finished thickness of from $\frac{1}{2}$ in. to 2 in., using wood strips. Boards of the maximum dimensions can be built up from strips 1 in. wide in about three minutes.

THE PARIS INTERNATIONAL AIR SALON.

(*Concluded from page* 44.)

LAST week we described the three French light jet training aircraft demonstrated at Le Bourget. This week, after referring to an engine development which may prove to be of great significance in both military and commercial spheres, we describe some of the latest French military and commercial machines displayed.

THRUST-SPOILERS.

An impressive demonstration of a jet thrust-spoiler device developed by the Société Nationale d'Étude et de Construction de Moteurs d'Aviation (S.N.E.C.M.A.), 150, Boulevard Haussmann, Paris (8e), was given by two Vampire aircraft, one of which was fitted with spoilers and one without. A powerful braking effect is given by the spoilers, which can be used not only for landing (analogous to reversing pitch on a propeller-driven aircraft) but also in flight to reduce thrust quickly and reinforce the effect of the air brakes. The Vampire with thrust spoilers was brought to rest, on landing, in a remarkably short distance and then proceeded to taxi tail first under reversed thrust. The manufacturers claim that a landing-run reduction of some 50 per cent. or more has been obtained with the Vampire installation, and that a shorter landing run can be obtained, by using reverse thrust alone, than is possible in a normal braked landing with engine idling. This development may prove to be the solution to the serious problem of landing jet-propelled aircraft on icy runways. Unfortunately, it is not possible to give details of the S.N.E.C.M.A. mechanism; the reverse-thrust effect is, however, achieved by a system of guide vanes at the jet exit, and the degree of reverse thrust can be controlled by the pilot. In the Vampire installation, determined by the twin tail-boom configuration, the jet is deflected into two balanced streams arranged symmetrically in relation to the horizontal plane through the thrust axis.

PULSE JETS.

S.N.E.C.M.A. also showed, in the static exhibition, their Escopette and Écrevisse pulse jets in which no mechanical valves are employed, the characteristics of the duct being designed to form an "aerodynamic" valve producing a pulsating gas flow with a frequency of about 60 cycles per second. The Escopette, illustrated in Fig. 6, was first seen at the 1951 salon and has since undergone many hours of test flying installed in an Emouchet sailplane, fitted with four or six such units. In this year's flying display an Emouchet sailplane powered by four Tromblon pulse jets, a more powerful development of the Escopette, was demonstrated in flight. The Escopette is 2,880 mm.

(113 in.) long, 157 mm. (6·2 in.) in diameter, weighs 4·8 kg. (10·6 lb.), and develops a static thrust of 10 kg. (22 lb.). The short curved tube in front of the air intake, known as the recuperator, reverses the gas flow through the flow valve at the time of the explosion. In the recently-developed Écrevisse pulse jet, illustrated in Fig. 7, the recuperator has been eliminated by forming the combustion chamber in a 180-deg. bend, so that the air intake is directed towards the rear. The prototype Écrevisse is 1,540 mm. (60·6 in.) long, weighs 6 kg. (13·2 lb.), and develops a thrust of 20 kg. (44 lb.). Another larger version, 2,480 mm. (97·5 in.) long and weighing 10 kg. (22 lb.), develops a thrust of 30 kg. (66 lb.) and has a specific fuel consumption of only 1·35 lb. per lb. thrust per hour.

"SE 5000 Baroudeur" Ground-Support Aircraft.

A model of an interesting new development, the SE 5000 Baroudeur, by Société Nationale de Constructions Aéronautiques du Sud-Est (S.N.C.A.S.E.), 24, Avenue Marceau, Paris (8e), was on view in the static exhibition; the full-scale prototype is illustrated in Fig. 5. The Baroudeur, a single-seat ground-attack aeroplane, is intended as a solution to the problem of providing a high-performance military aircraft capable of operation from forward areas without the necessity for long concrete runways. For take-off, it utilises a launching trolley, and it lands on retractable skids.

The trolley comprises, in effect, a rocket-propelled tricycle undercarriage with castoring twin nose-wheels and single main wheels mounted, on rubber-block shock absorbers, on a welded-steel chassis frame. Low-pressure tyres are fitted, and the rear wheels are provided with brakes which can be operated by the pilot during the ground run, and which are automatically brought into action when the aircraft is released from the trolley. In addition, the trolley is provided with arrester forks, which automatically bring it quickly to rest after the aircraft has taken off. Six rockets are mounted on two longitudinal outriggers extending beyond the rear chassis member. Normally, two to four rockets are used for take-off, depending on the terrain, and two are held in reserve.

The method of mounting the aircraft on the trolley is quite simple and speedy: the trolley is backed up to the nose of the aircraft by a jeep, provided with a winch. The aircraft is winched on to the trolley, running on guide rollers mounted on the front and rear members of the trolley; side stays also assist in guiding the aircraft. The latter is then attached to the trolley by a quick-release mechanism operated by the pilot when take-off speed is obtained.

As may be appreciated from Fig. 5, the Baroudeur provides an excellent forward view over the sharply-sloping nose. It has been designed for simple construction and for serviceability by grouping the equipment and providing large access panels. It is a high-midwing monoplane with swept-back wing and tail surfaces. The prototype aircraft is fitted with a S.N.E.C.M.A. Atar 101 jet engine installed in the fuselage with wing-root intakes; the fuselage has, however, been designed to allow the installation of alternative engines such as the Hispano-Suiza Avon. A variable-incidence tail-plane is fitted, operated by a two-speed electric actuator. As on most current French designs, the control surfaces are operated by a Jaccotet-Leduc hydraulic servo system. The ailerons are aero-dynamically balanced, and high-lift slotted flaps and dive brakes, specially designed to be highly effective, are fitted inboard of the ailerons. The landing gear comprises two forward skids and a rear skid, mounted on shock-absorbing rubber blocks operating in torsion, and rubber compression blocks to give the cushioning normally provided by the tyres. The Baroudeur has a span of 10 m. (32·8 ft.), an overall length of 13·49 m. (44·4 ft.), and an overall height of 3·04 m. (10 ft.) on its skids and 3·60 m. (11·8 ft.) on the trolley. No performance details are available, other than the fact that it requires a run of only 700 m. (760 yards) for take-off. Various alternative forms of armament can be fitted, for ground-attack or for bombing duties, and the aircraft is highly protected by armour plating.

An earlier prototype ground-attack or all-weather fighter aircraft designed by S.N.C.A.S.E., the SE 2410 Grognard 1, was demonstrated in flight. This machine, which has never gone into production, flew for the first time in 1950. It is a swept-back mid-wing monoplane powered by two Hispano-Suiza Nene engines, both installed within a deep fuselage, one above the other, the air intake being in the top of the fuselage aft of the cabin. The Grognard 1 has a span of 13·581 m. (44·5 ft.), a length of 15·435 m. (50·8 ft.), a height of 2·651 m. (8·58 ft.), and a wing area of 46·14 sq. m. (495 sq. ft.). The take-off weight is 14,600 kg. (31,000 lb.) The aircraft has a maximum speed of 1,050 km. per hour (650 m.p.h.) at sea level, and an initial rate of climb of 27 m. per second (5,350 ft. per minute).

"Potez 75" Ground-Support Aircraft.

An unusual conception for a ground-support aircraft, armed with guided missiles, for home defence against an invading army, and suitable for operation by pilots of limited experience, is the Potez 75, designed and constructed by Société des Avions et Moteurs Henry Potez, 46, Avenue Kléber, Paris (16e). The Potez 75 is illustrated in Fig. 8, on Plate V, from which it will be apparent that speed is a secondary consideration. The main features are simplicity of construction and operation, sturdiness, and economy. It is noteworthy that the project was first conceived in the spring of 1952; construction commenced in January 1953, and the aircraft made its maiden flight on June 10.

The Potez 75 carries a crew of two, the observer being accommodated in an enclosed cabin in the nose of the aircraft and the pilot in an open cockpit above and aft of the observer. The aircraft, of all-metal construction, is powered by a Potez 8D 450-h.p. engine installed in the rear of the fuselage and driving a pusher propeller. The aircraft is heavily protected by armour plating against attack from the ground. It has a fixed tricycle undercarriage. The span is 13 m. (42·5 ft.) and the overall length 9·1 m. (29·8 ft.); the tare weight is 1,675 kg. (3,700 lb.) and the all-up weight 2,400 kg. (5,300 lb.). The cruising speed is 245 km. per hour (150 m.p.h.) and the range is 750 km. (465 miles).

"SO 4050 Vautour" Twin-Jet Military Aircraft.

France has three aircraft destined for her air force that have already demonstrated their ability to overcome the "sound barrier," and a recent experimental machine is expected to be capable of supersonic speed in level flight. Illustrated in Fig. 9, on Plate V, is the transonic SO 4050 Vautour twin-jet single-seat or two-seat aeroplane, shown landing with its tail parachute extended, designed and constructed by the Société Nationale de Constructions Aéronautiques de Sud-Ouest (S.N.C.A.S.O.), 105, Avenue Raymond-Poincaré, Paris (16e), and intended for various roles, such as ground support, light bombing duties, all-weather fighter, or reconnaissance. The Vautour flew for the first time in October, 1952, and it is probable that production will commence in the near future. Recently, it exceeded the speed of sound in a dive, and it has been stated that it can carry an atomic bomb over a distance of 2,000 km. (1,250 miles). No other performance data have been released officially. The prototype is powered by two S.N.E.C.M.A. Atar 101B axial-flow jet engines, each developing a static thrust of 2,500 kg. (5,500 lb.). The engines are fitted in conventional nacelles, which have been designed to permit the installation of considerably more powerful engines, e.g., the Armstrong-Siddeley Sapphire, slung below a swept-back wing of very thin section.

The wings and tail surfaces are of torsion-box construction, with a heavy-gauge skin and stringers bonded by a special process developed by S.N.C.A.S.O. The control surfaces are actuated by an irreversible servo system. The dive brakes are mounted in the rear of the fuselage. The under-carriage is of an unusual type, developed by Société d'Exploitation des Matériels Aéronautiques Hispano Suiza, Rue du Capitaine Guynemer, Bois-Colombes (Seine), with "bicycle" main double-wheeled units retracting in tandem into the fuselage and small wing wheels accommodated in the nacelles. The cockpits are pressurised and armour-protected and are provided with ejector seats. The fuel tanks, radio compartment and power plants are also protected by armour plating at the rear and on the sides. There is provision for carrying two to four drop tanks.

"SO 9000 Trident" Experimental Supersonic Aircraft.

An aircraft of unorthodox layout is the SO 9000 Trident experimental machine designed and constructed by S.N.C.A.S.O., which is intended to build up experience for the design of a light-weight supersonic interceptor fighter aircraft of comparatively low cost. It is the first French aircraft designed for level flight at speeds greater than that of sound. It flew for the first time in March this year. The Trident, which is illustrated in Fig. 10, on Plate V, has itself been designed as a fighter, but carries no armament, being extensively equipped with test instruments. It is powered by a Serp rocket motor (the performance of which has not been stated) installed in the rear fuselage, and two Turboméca Marboré jet engines, each developing 400 kg. (883 lb.) static thrust, fitted to the wing tips. At Le Bourget, the Trident was flown on the Marborés only. As in the Vautour, a mid-wing layout has been adopted, with a very thin wing section, but in this case the wing has a straight rectangular plan form and is of low aspect ratio. The tailplane, which has a noticeable anhedral, and the fin, are both all-moving surfaces. "Sandwich" construction has been largely adopted. The control surfaces are actuated by an irreversible hydraulic servo system developed, as was also the propulsive system, on earlier prototype aircraft by S.N.C.A.S.O. A tricycle undercarriage of unusually narrow track, dictated by the necessity to accommodate the main units within the fuselage, is fitted. The fuselage is cylindrical in section, and for emergency exit in flight the entire nose section, including the cockpit, can be jettisoned.

Dassault "Mystère" Fighter Aircraft.

Both the Mystère II and IV single-seat fighter aeroplanes, designed by Avions Marcel Dassault, 46, Avenue Kléber, Paris (16e), were demonstrated. The former aircraft, a swept-wing development of the Dassault Ouragan fighter, was the first French aircraft to exceed the speed of sound. Two prototype Mystère II aircraft, powered respectively by a Hispano-Suiza Tay jet engine developing 2,850 kg. (6,250 lb.) static thrust, and a S.N.E.C.M.A. Atar 101C jet engine developing 2,800 kg. (6,200 lb.) static thrust, flew for the first time during 1952; a two-seat night fighter variant also flew. The version demonstrated at the Salon has a Tay engine. The span is 11·62 m. (38·1 ft.), the length 11·68 m. (38·6 ft.), and the wing area 30·3 sq. m. (325 sq. ft.). The Mystère IJ is armed with two 30-mm. guns and has an all-up weight of 6,500 kg. (14,200 lb.). The maximum speed at sea level is 1,080 km. per hour (675 m.p.h.), and the initial rate of climb is 48 m. per second (9,500 ft. per minute).

The Mystère IV, with a redesigned fuselage and Messier undercarriage, wings of greater sweep-back, and larger tail surfaces than the Mystère II, to give an enhanced performance, made several passes through the sound barrier on the last day of the Salon. It is illustrated in Fig. 11, on Plate V. The prototype aircraft is fitted with a Tay engine; both Tay and Atar-powered machines are to be produced (a total of 225 aircraft have been ordered), and later this year it is expected that an Avon-powered aircraft, the Mystère IVB, will fly. The aircraft is armed with two 30-mm. guns and rocket batteries. The cockpit is armoured and pressurised, and provided with an ejector seat. Jaccotet hydraulic power-operated controls are fitted. The dive-brakes are on the fuselage. The all-up weight is said to be about 8 metric tons, and the endurance ranges from 1 to 3 hours, according to the duties on which the aircraft is engaged. No other details of performance have been released.

Breguet "Vultur" Naval Strike-Fighter Aircraft.

Another aircraft of unusual configuration is the Breguet 960 Vultur two-seat naval strike-fighter,

(To face page 74.)

EXHIBITS AT THE PARIS AIR SALON.

(*For Description, see Page* 73.)

FIG. 8. "POTEZ 75" GROUND-SUPPORT AIRCRAFT.

FIG. 9. "SO 4050 VAUTOUR" TWIN-JET MILITARY AIRCRAFT.

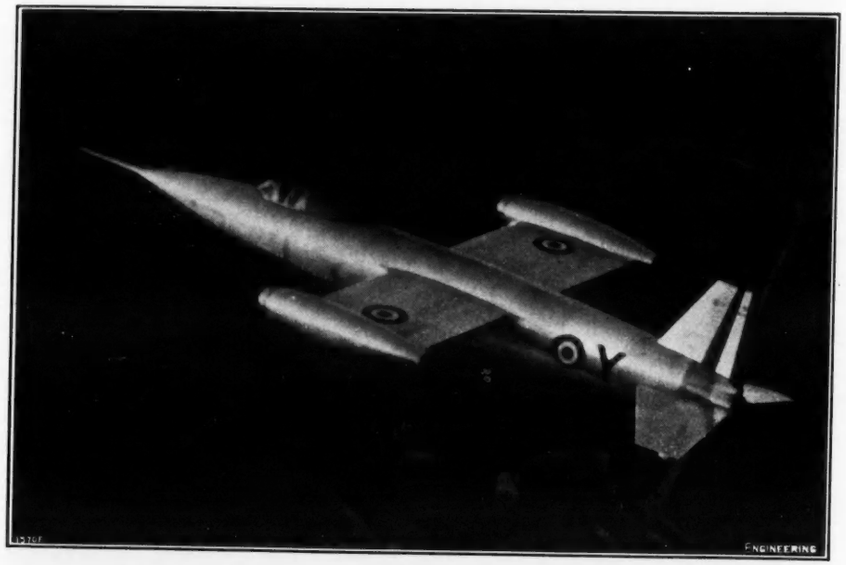


FIG. 10. "SO 9000 TRIDENT" EXPERIMENTAL SUPERSONIC AIRCRAFT.

FIG. 11. DASSAULT "MYSTÈRE IV" FIGHTER AIRCRAFT.

EXHIBITS AT THE PARIS AIR SALON.

(*For Description, see Page* 73.)

FIG. 12. BREGUET "VULTUR" NAVAL STRIKE-FIGHTER AIRCRAFT.

FIG. 13. "SE 3120 ALOUETTE" HELICOPTER.

FIG. 14. "SO 1220 DJINN" HELICOPTER.

FIG. 15. "SO 1310 FARFADET" CONVERTIBLE AIRCRAFT.

(*To face page* 75.)

EXHIBITS AT THE PARIS AIR SALON.

FIG. 16. "HUREL-DUBOIS 31" AIR-LINER.

designed, for operation from aircraft carriers, by Société Anonyme des Ateliers Louis Breguet, 24, Rue Georges Bizet, Paris (16e). To provide the operational flexibility essential in a deck-borne aircraft, which must be capable of long-duration flights and must also have ample power for take-off and for pursuit, the Vultur is fitted with an Armstrong-Siddeley Mamba propeller turbine, developing 1,320 h.p. plus 400 lb. thrust, installed in the forward part of the fuselage, and a Hispano-Suiza Nene jet engine, developing 2,400 kg. (5,300 lb.) static thrust, installed in the rear fuselage. For patrol duties, the aircraft is normally propelled by the Mamba alone, the Nene being used to give additional power for take-off and combat. Two prototypes have been built.

From Fig. 12, on Plate VI, it will be seen that the Vultur is a low-wing monoplane with side-by-side accommodation for the pilot and observer. Ejector seats are provided. The wings can be folded for deck stowage, and a tricycle undercarriage is fitted. The Vultur has a span of 16·7 m. (51 ft.), a length of 15·35 m. (50 ft.), a height of 5·17 m. (17 ft.), and a wing area of 36·55 sq. m. (393 sq. ft.). The all-up weight is 9,800 kg. (21,600 lb.). The maximum speed, with both engines in action, is 850 to 900 km. per hour (about 550 m.p.h.), and with the Mamba alone, 400 km. per hour (250 m.p.h.). The service ceiling is 13,000 m. (43,000 ft.). The endurance, on the Mamba engine alone, is 4 hours 30 minutes, and cruising at 700 km. per hour (435 m.p.h.), on both engines, the endurance is one hour. The landing speed is 155 km. per hour (97 m.p.h.).

"SE 3120 ALOUETTE" HELICOPTER.

Two of the French national companies displayed helicopters. Fig. 13, on Plate VI, shows the SE 3120 Alouette, designed and constructed by S.N.C.A.S.E. During the show, this machine established an international record for distance in a closed circuit for helicopters of all categories, at 1,252 km. (780 miles), over the circuit Buc-Etampes-Rambouillet-Buc, at an average speed of 108 km. per hour (68 m.p.h.). The previous record of 1,000 km. was held by a Sikorsky S 51 helicopter. The Alouette is a three-seat general-purpose helicopter powered by a 200-h.p. Salmon 9NH engine driving a three-blade rotor of 11·6 m. (38 ft.) diameter, and a two-blade anti-torque rotor, 2 m. (6·6 ft.) in diameter. The overall length of the machine is 10·45 m. (34·25 ft.), the height is 2·90 m. (9·5 ft.), and the width 2·62 m. (8·6 ft.). It has a service ceiling of 3,600 m. to 4,000 m. (11,800 ft. to 13,000 ft.), and a hovering ceiling of 1,300 m. (4,300 ft.). The rate of climb is 4·5 m. per second (890 ft. per minute), and the rate of descent, in auto-

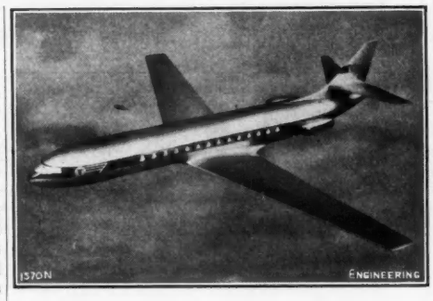


FIG. 17. MODEL OF "SE 210 CARAVELLE" AIR-LINER.

rotation, is 6 m. per second (1,190 ft. per minute). The Alouette has a maximum speed of 125 km. per hours (78 m.p.h.) and a normal endurance of 2 hours 15 minutes. S.N.C.A.S.E. also demonstrated the Sikorsky S 55 helicopter that they are about to produce under licence—not, as stated on page 50, *ante*, the S 51 helicopter; we regret the error.

"SO 1220 DJINN" HELICOPTER.

Known as the "motor bicycle of the air," the SO 1220 Djinn helicopter, demonstrated by its constructors, S.N.C.A.S.O., aroused much interest by its compressed-air rotor-tip drive, which has a remarkably low noise level and suggests a possible solution to the problem confronting those operators who have encountered opposition to the establishment of city helicopter bases on the score of noise. The Djinn, at present a single-seat machine, is illustrated in Fig. 14, on Plate VI. The compressed air supplying the blade-tip jets is provided by a Turboméca Paluste turbo-compressor. The exhaust from the turbine is ejected through the tail end of the helicopter, and movement of the rudder deflects the exhaust stream, thus providing excellent directional control during vertical flight, when the rudder surface itself is not effective. Later, a two-seat version of the Djinn is to be mass-produced, weighing about 500 kg. (1,100 lb.), with an endurance of about three quarters of an hour. It will have a hovering ceiling of 1,000 m. (3,280 ft.) and a cruising speed of 100 km. per hour (62·5 m.p.h.).

"SO 1310 FARFADET" CONVERTIBLE HELICOPTER.

S.N.C.A.S.O. also showed, in the static display only, their SO 1310 Farfadet "convertible" aircraft, which made its first flight in May this year. The Farfadet, illustrated in Fig. 15, on Plate VI, has been built to investigate the possibilities of the configuration for commercial use. It can take off, hover and land as a helicopter, but has the advantage of a higher forward speed. The Farfadet has a compressed-air rotor-tip drive supplied by a Turboméca Arrius II 360-h.p. turbo-compressor installed in the fuselage aft of the cabin. For cruising flight, the aircraft is supported primarily by a 19-ft.-span fixed wing, in which the fuel tanks are housed, and is propelled by a Turboméca Artouste II propeller-turbine, developing 360 h.p. under take-off conditions, which drives a conventional two-blade variable-pitch propeller. During forward flight, the rotor drive is shut down and the rotor continues to turn in auto-rotation.

The Farfadet is provided with two pilots' seats and dual controls; aft of the pilots' stations, the cabin can accommodate three passengers, freight, or two stretchers one above the other. With pilot and two passengers on board, the Farfadet has a maximum range of about 400 km.(250 miles), at a cruising speed of 240 km. per hour (150 m.p.h.).

"HUREL-DUBOIS 31" AIR-LINER.

A development pioneered by France, notably by the Société Anonyme des Avions Hurel-Dubois, Route de Verrières, Meudon, is the large-span wing of ultra-high aspect ratio for applications where exceptionally good low-speed and take-off characteristics and economical cruising are required. An impressive demonstration of the slow-flying, take-off and landing abilities of the Hurel-Dubois 31 air-liner, which flew for the first time in January, was given at Le Bourget. This aircraft, which is illustrated in Fig. 16, has been designed primarily for operating over short to medium stages in countries where runways and maintenance facilities are limited. It provides accommodation for up to 42 passengers. It is powered by two Wright C.7 BA.1 engines, each developing 800 h.p., but a later version, the HD 32, which is expected to fly this autumn, will have 1,200-h.p. Pratt and Whitney R-1830-92 engines, i.e., of the same type as those fitted in the D.C.3.

The monoplane wing of the HD 31, which has a span of 148 ft. and an aspect ratio of 20·0, comprises a constant-chord centre section, passing through the fuselage and bearing the two engine nacelles, and two outer wings which are removable. It is of single-spar construction. Two lower stub wings attached to the fuselage take the drag loads from the main wheels of the fixed tricycle undercarriage, and are braced to the outer main wing by articulated struts of aerofoil section, which make some contribution to lift. It is braced also to the centre section by vertical struts at the nacelle locations, which also serve to fair the main-wheel shock absorbers. The flaps are of the double-slotted type, extending over 70 per cent. of the span, and lift-spoilers are provided which are brought into action to reduce the landing run when the aircraft touches down. Both flaps and spoilers are hydraulically operated. All the control surfaces are balanced, and the elevator and ailerons are provided with adjustable tabs. The elevator and rudder control cables are duplicated for safety. The fuselage, which has an overall length of 72 ft., is built in three sections, the nose, housing the flight deck, the passenger cabin, and the rear section, carrying the tail surfaces. The cabin has a volume of 44 cub. m. (1,554 cub. ft.) above the floor, and a total volume available for freight of 50 cub. m. (1,765 cub. ft.). The floor area is 22 sq. m. (236 sq. ft.). The seats can face either forward or backward, and are arranged for quick removal, thus providing for versatility of role.

The all-up weight of the machine is 13,500 kg. (30,000 lb.) and the maximum cruising speed is 290 km. per hour (180 m.p.h.) at 3,000 m. (9,850 ft.). The recommended cruising speed is some 20 km. per hour (12 m.p.h.) slower. The aircraft can carry a payload of 2,500 kg. (5,500 lb.) over a stage length of 2,000 km. (1,250 miles), and 4,000 kg. (8,800 lb.) over a stage length of 500 km. (310 miles). The distance required to take off and clear a 50-ft. obstacle is 500 m. (550 yards), and the landing run is 245 m. (270 yards). The higher-powered HD 32 aircraft, which weighs some 6,000 lb. more than the HD 1, can carry approximately an additional

5,000 lb. of payload over the corresponding stage distances, at a recommended cruising speed some 10 m.p.h. higher.

"SE 210 CARAVELLE" AIR-LINER.

Another unconventional air-liner, the twin jet-propelled Caravelle, now under construction by S.N.C.A.S.E., was shown in model form. The model Caravelle is illustrated in Fig. 17. Two prototypes have been ordered by the Secrétariat Général à l'Aviation Civile et Commerciale. The Caravelle is designed to carry 70 passengers, over medium stage lengths, at a cruising speed of about 750 km. per hour (470 m.p.h.), and will have an all-up weight of about 38,000 kg. (86,000 lb.). The unusual feature of the Caravelle, which is a low-wing monoplane of pleasing lines, with slightly swept-back wing and tail surfaces, is the power plant installation. The use of only two engines to power an aircraft of this size is in itself unorthodox, but, in addition, the two Rolls-Royce Avon RA-16 jet engines, each developing 9,000 lb. thrust, are installed in nacelles on each side of the rear end of the fuselage, just forward of the tailplane, which is set above the fuselage on the fin. The rear location of the power units should give an unprecedentedly low cabin sound level, and should provide excellent accessibility for servicing and changing the engines. It also increases the space available in the wings for fuel stowage; the Caravelle has a total fuel capacity of 20,000 litres (4,400 gallons) of fuel, carried in wing tanks.

CONCLUSION.

Among other exhibits on view in the hall, brief mention should be made of the 400-cycle aircraft electrical system developed by S.N.C.A.S.O., using auxiliary air turbines to drive a 6-kVA alternator, or a Turboméca Oredon 160-h.p. turbine to drive a 40-kVA alternator. This company have also developed an auxiliary jet unit of light weight, based on the Turboméca Palas jet engine, for providing additional take-off thrust for air-liners, to improve their take-off run for a given weight, or to allow additional payload to be carried.

The immediate impression left by a visit to the French aircraft industry's exhibition is of the wide diversity of approach to design. Underlying this diversity, however, there is evidence of a growing appreciation of the possibility that the modern military jet aircraft is becoming too costly and complicated to construct and operate under war conditions. France, now beginning to play an important part in aircraft production, has provided a stimulating experience for the aeronautical world.

REGISTER OF SPECIALIST INDEXERS.—To assist authors and publishers in indexing their published works, Aslib, 4, Palace-gate, London, W.8, is establishing a register of part-time specialist indexers. They will be enrolled in two categories: those who can produce evidence of indexing ability, and those who appear to possess the necessary qualifications but who have no published indexes to their credit. In both cases, evidence of special knowledge of one or more subjects will be required. All indexing work negotiated through the Aslib register will be subject to scrutiny to ensure that the register becomes and remains a recognised source of reliable subject indexers. Publishers requiring information and suitably qualified indexers wishing to enrol on the register should apply to the Director, at the address given above.

INSTITUT INTERNATIONAL DU FROID.—A recent issue of the *Bulletin* of the International Institute of Refrigeration contains reprints of the papers delivered at a meeting of Technical Commissions Nos. 1 and 2 of the Institute, held in Louvain, Belgium, on June 9, 10 and 11, 1952. The papers, most of which are in English, although a few are in French, deal with problems relating to thermal conductivity. The *Bulletins*, which summarise, in English and French, the articles on refrigeration appearing in about 200 publications, can be obtained from Mr. J. Raymond, Refrigeration House, Victoria-road, Woking, Surrey. A meeting of the first and second commissions of the Institute will be held this year in Zürich, on September 10, 11 and 12, and will deal with the practical applications of low temperatures. Dr. Ezer Griffiths, of the National Physical Laboratory, is president of the second Commission.

YEAST FACTORY AT DOVERCOURT.

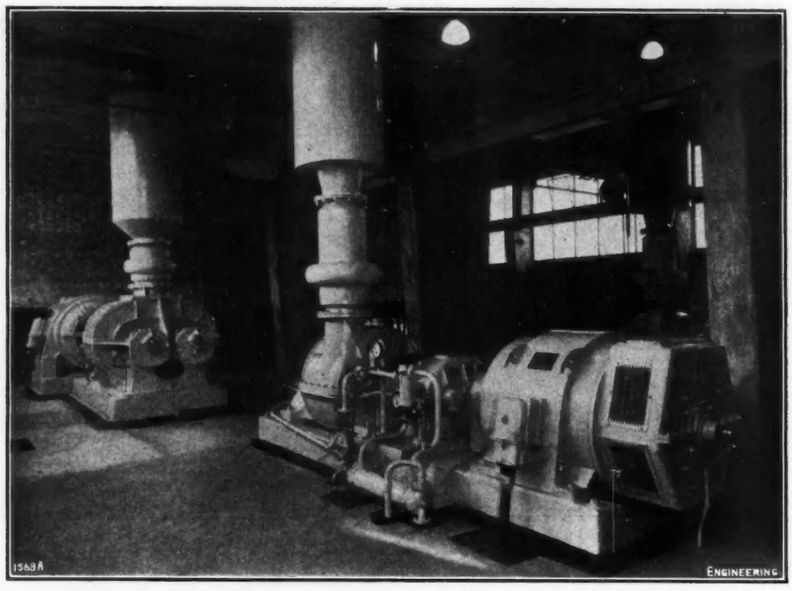
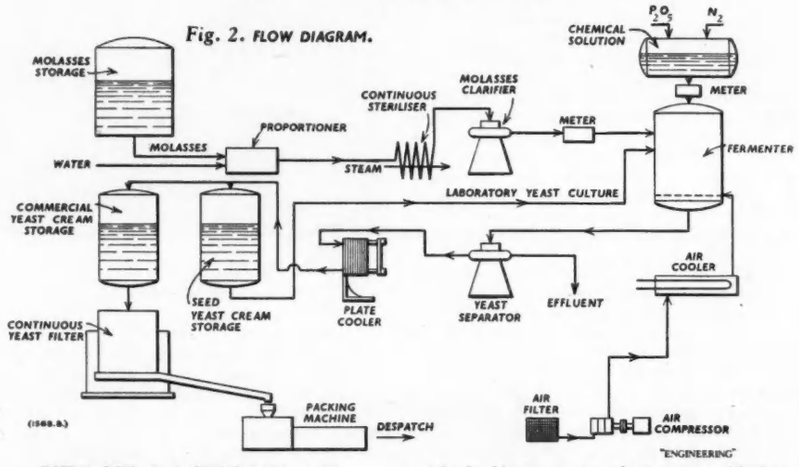


FIG. 1. PART OF THE BLOWER ROOM.

Fig. 2. FLOW DIAGRAM.



YEAST FACTORY AT DOVERCOURT.

A MODERN yeast factory—like other installations for processing and handling foodstuffs—makes full use of plant and equipment that is employed in other industries, but it also has requirements involving specialised design and modifications to the equipment that are peculiar to this particular industry. The emphasis in design is on hygiene and the exclusion of unwanted organisms which might affect the pure yeast cell during growth or infect the final product. When the yeast has grown in bulk, the product is a living organism which must be packed and dispatched in such a way that it retains its vitality and is protected from contamination, so that it is still pure and active when required for use.

In building the yeast factory for the Standard Yeast Company, Limited, at Dovercourt, Essex, the designers had the advantage of a fresh site, unencumbered by other buildings, and a determined effort was made to construct and equip a factory embodying all the requirements that recent experience and opinion demanded. A description of the factory, which is of modern appearance and incorporates a number of novel structural features, but not of the plant and equipment, has already been published in ENGINEERING, page 220, volume 175 (1953). The present article is concerned primarily with the plant and equipment.

The buildings consist of three main blocks: the offices, laboratories for inspection and research, together with a drawing office in one block; the principal processing block that is built over the raw material stores and contains the fermentation tanks; and the third block, where the yeast is extracted, packed and dispatched. All materials are received into the factory over a weighbridge and are delivered to the processing block. The materials are then passed through the plant with the least possible handling, and the finished product is loaded into refrigerated vehicles at the opposite end of the factory. The principal raw material, molasses, is obtained from nearby sugar factories, and all the water is drawn from boreholes sunk on the site; the effluent is discharged into the estuary of the River Stour on the ebb tide and reservoirs have been constructed to store the effluent while the tide flow is inwards. A flow diagram showing the basis of the processes is given in Fig. 2, herewith.

Molasses are employed as the sole source of carbohydrates into which a refined yeast culture is introduced to bud and multiply as the molasses ferment. The molasses from various suppliers are discharged from road tankers into a number of steel-lined storage tanks built into the cellular foundation of the processing block; the use of several independent storage tanks enables the different types of molasses to be stored separately and also permits frequent emptying and cleaning of the tanks.

YEAST FACTORY AT DOVERCOURT.

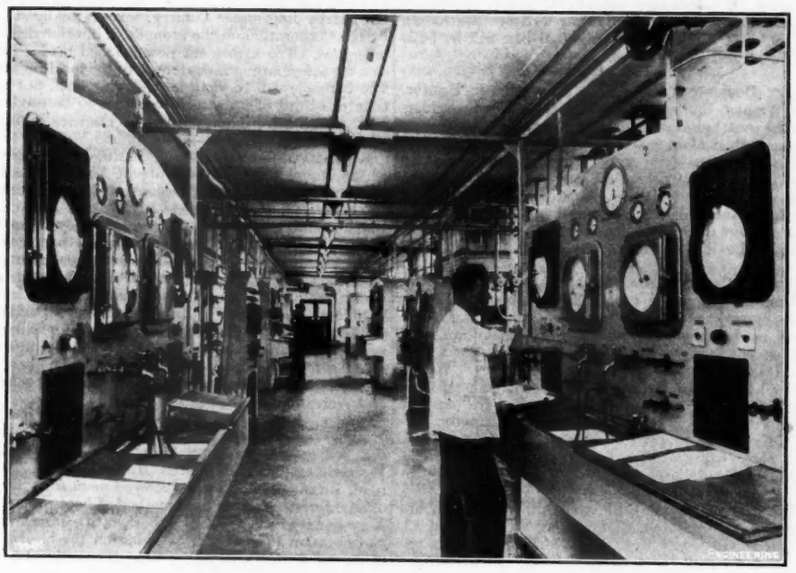


FIG. 3. CONTROL ROOM FOR FERMENTATION PLANT.

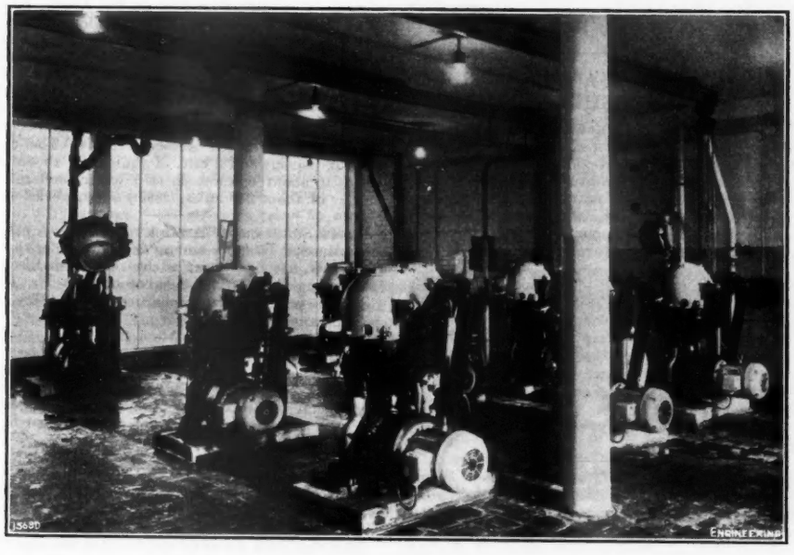


FIG. 4. CENTRIFUGAL SEPARATORS AND WASHERS.

From one or more of these storage tanks, molasses are drawn directly to a proportioning pump, driven by a 2½-h.p. motor, which dilutes the molasses with water at a steady rate of between one and two tons of solution per hour throughout the week. From the proportioning pump, the molasses solution is subjected to a sterilising process, the supply line from the pump to the clarifier acting as the sterilising vessel. After clarification, the solution is passed through control meters, which automatically adjust the flows at the proportioning pump to bring the solution to a predetermined degree of sugar concentration. The solution then flows to feed tanks located above the fermentation vessels. The whole process of pumping from the storage tanks and supplying the sterile molasses solution to the fermentation vessels is continuous and requires no supervision (except at the clarifiers); the speed of the proportioning pump and the rate of sterilisation is automatically controlled and synchronised to the flow into the vessels.

Solid chemicals are required as a source of nitrogen and phosphate; these solids, such as ammonium sulphate and phosphates, and magnesium sulphate, are taken directly from the delivery vehicles to the chemical stores at the top of the building by sack elevator. Liquid chemicals, including ammonia liquor, sulphuric acid and anti-froth oil, are discharged from road tankers into bulk-storage tanks below the roadway. From the top floor, the ammonium sulphate and other salts are put into solution, which is maintained at a pre-selected gravity, and the rate of flow is adjusted to satisfy the main fermentation requirements.

The ten fermentation vessels are of stainless steel and are cooled by external water jackets, thus leaving the interior of the vessels free from obstructions except for aeration pipes at the bottom. The aeration device and the bottom of the vessels have been specially designed for this plant to facilitate cleaning. The bottom of the vessel is so constructed that it is possible to introduce a telescopic rotating sprayer through which hot water at high pressure is forced; by this means, it is possible to clean a vessel in a short time and without men entering the vessel. An interesting feature of the design of the factory layout is the location of the fermentation vessels partly outside the processing block, with only the top protruding into the control room within the building. This arrangement resulted in a considerable reduction in the size, and therefore the cost, of the building.

The quantity of air passed into the vessels is adjusted by a simple type of valve with a remote finger-tip control. About 15,000 cub. ft. of free air per minute are required for processing and both high-speed turbo-blowers and low-speed positive-displacement blowers have been installed for this purpose. A view of part of the blower room is given in Fig. 1, opposite. The blowers are driven by constant-speed and variable-speed 300-h.p. motors; power-factor correction equipment connected to smaller motors distributed throughout the factory enables the overall power factor to be kept close to unity.

A control panel has been installed for each fermentation vessel with all the instruments required for the control of the process, as it relates to a particular vessel, being brought together on to one panel. The instruments include liquid dip gauges, air and temperature recorders, thermostatic control of the cooling water in the jackets of the fermentation vessels, flow controllers for all the ingredients, and sampling devices. With indicator panels connected to other parts of the factory showing the state of the process at all points in the system also installed in the same control room, shown in Fig. 3, herewith, it is possible for two men to be in complete control of the factory. Fermentation loads are pre-set day and night to keep production in step with demand and to run the plant continuously at nearly steady rates.

After fermentation, the contents of the vessels are pumped to totally-enclosed centrifugal separators where the yeast cream is extracted and washed; a view of one corner of the separator room is shown in Fig. 4. The yeast concentrate is then discharged from the separators through plate coolers which reduces the temperature to just above freezing point. The cold concentrate is then stored temporarily in insulated vessels of stainless steel; like the fermentation vessels, these are also partly located outside the buildings.

To meet the differing demands of home and overseas buyers, two types of filter equipment and packaging are employed, namely, frame presses with pressure plattens, and continuous vacuum filters, the latter being used to produce dessicated yeast that is packed in transparent plastic pouches and is suitable for use overseas after long periods of storage. From the filter plant and frame presses, the yeast passes through automatic forming, cutting and wrapping machines, and wrapped one-pound blocks are then hand packed into cartons which pass through a continuous sealing machine and then along a conveyor system to the cold store. From the cold store, the packed yeast can be loaded directly into refrigerated vehicles that are backed up to discharge ports in the wall of the cold store; in this way the makers ensure that the yeast leaves the factory in good condition and at the correct temperature. The capacity of the factory is about 10,000 tons of high-quality bakers' yeast per annum.

The design of the factory installation and of much of the equipment is the work of Mr. A. J. C. Olsen, M.I.Chem.E., of the Standard Development Company, Limited, King George's-avenue, Dovercourt, Essex. The plant and equipment have been made by various sub-contractors, but the installation of the plant has been undertaken by the designing company.

STUDENTS' PRODUCTION ENGINEERING CONVENTION.—The Institution of Production Engineers, 36, Portman-square, London, W.1, has arranged to hold its second national convention for graduates and students of the Institution in the Chemistry Theatre, The University, Birmingham, on Saturday, September 5, 1953, when the theme "Engineering Production: Responsibilities and Opportunities," will be discussed. A similar convention took place at the same university in 1949. Although intended primarily for junior members of the Institution, senior members, and visitors who do not belong to the Institution, are invited to attend. The inclusive fee, including meals, is 10*s.* 6*d.* Application forms and further information may be obtained from the convention secretary, Mr. T. Houghton, 86, Crompton-road, Handsworth, Birmingham, 20.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

IMPROVEMENT SCHEME FOR GLASGOW HARBOUR.—The Clyde Navigation Trust decided on July 7 that five new improvement schemes are to be carried out at Glasgow harbour. The cost is estimated to be 1,904,000*l*. The projects include the building of a new storage shed at Meadowside and the installation of eight cranes; new sheds at King George V Dock; 24 cranes and crane tracks to be reconstructed at Queen's Dock and Stobcross Quay; and five new cranes and grabs at Rothesay Dock. The consideration of a suitable date for the commencement of a new 8,000,000*l*. basin, west of King George V Dock, has been deferred.

SHIPBUILDING IN SCOTLAND.—Ships to the number of 29 and aggregating 185,113 tons, were launched on the Clyde during the first six months of this year, against 34 ships, totalling 225,243 tons, in the first half of 1952. Corresponding figures for the East of Scotland this year were 13 ships, comprising 35,236 tons, an increase of nearly 1,500 in tonnage, but one ship fewer than in 1952.

FRAME FOR TESTING SHIPS' STRUCTURES.—On July 20, Mr. J. P. L. Thomas, First Lord of the Admiralty, is to inaugurate a large frame for testing ships' structures, built for the Admiralty at the Naval Construction Research Establishment, Dunfermline. Hydraulic jacks incorporated in the frame can simulate the pressure which a ship might meet in heavy seas, and, through recording devices, the amount of strain a ship's hull will withstand can be assessed. The first task to be carried out in the new frame will be a test of the bow structure supporting the steam catapults in the aircraft carrier Ark Royal. The testing installation will be available also for investigating commercial and civil-engineering problems.

ROYAL SOCIETY OF EDINBURGH AWARDS.—On July 6, Professor A. C. Aitken, F.R.S., of the Department of Mathematics, Edinburgh University, was awarded the Royal Society of Edinburgh Gunning Victoria Jubilee Prize for 1948 to 1952, for his contributions in the field of pure mathematics. Mr. G. de Q. Robin, lecturer in physics at Birmingham University, received the Dr. W. S. Bruce Memorial Prize for 1952, for his initiative in carrying out glaciological and meteorological researches in the Antarctic while with the Falkland Islands Dependencies Survey of 1946-47, and the Norwegian-British-Swedish expedition of 1950-51.

SHUTTLES FOR THE JUTE INDUSTRY.—India's almost complete embargo on the import of shuttles for the jute industry has threatened Ordie Mill, Luncarty, Perthshire, with closure after 110 years. The mill is shut down temporarily and the property has been offered for sale, but it is understood that no definite decision has yet been made by the owners, Peter McFarlane and Sons.

GLASGOW PRODUCTIVITY COMMITTEE.—After the inaugural meeting of the Glasgow Productivity Committee, on July 2, Mr. John Malley, a director of the Mirrlees Watson Co., Ltd., who presided, said that provincial committees were expected to go ahead under their own volition, devising their own procedure unhindered by any hard-and-fast rules. To begin with, they would not attempt any elaborate programme, but as operatives and foremen in all industries had probably had fewer opportunities than others to learn what was expected, the first public meeting to be held, later this year, would be designed to appeal principally to them.

BERWICK AND EYEMOUTH SHIPYARDS FOR SALE.—The shipbuilding yards of William Weatherhead & Sons, Limited., at Berwick-on-Tweed and Eyemouth, are being offered for sale, the company having gone into liquidation. The yard at Berwick-on-Tweed is suitable for the building of steel and wooden craft up to 120 ft. in length, while that at Eyemouth can deal with vessels up to 70 ft. long. Both are fully equipped.

CLEVELAND AND THE NORTHERN COUNTIES.

INSTALLATION OF COLOUR-LIGHT SIGNALLING AT NEWCASTLE CENTRAL STATION.—British Railways have received permission from the British Transport Commission to proceed with a 780,000*l*. scheme for the installation of colour-light signalling at Newcastle-on-Tyne Central Station. During the next four years, it is hoped to replace 330 semaphore signals by lights. Four existing signal boxes, equipped with a total of 538 levers and 34 switches, are to be replaced by one electrically-operated signal box controlling 641 route switches, 94 colour-light signals, 87 ground subsidiary signals, and 132 individual points switches controlling ten miles of track. The new signal box will be built on Nos. 9 and 10 platforms.

DRY DOCKS FOR LARGE TANKERS.—Swan, Hunter, and Wigham Richardson, Ltd., Wallsend, are considering the construction of a dry dock capable of accommodating tankers of up to 40,000 tons deadweight capacity. The scheme has been under consideration for some time. At present, the firm have three docks, the largest being 570 ft. long. At present, Smith's Dock Co. Ltd., North Shields, are building a dock which will take tankers of 38,000 tons, and this is expected to be completed early in 1954.

URGENT CALL FOR ELECTRICAL BREAKDOWN REPAIR.—Messrs. A. Reyrolle & Co., Ltd., Hebburn-on-Tyne, have expeditiously dealt with an inquiry for spare parts needed to repair an electrical breakdown at a Belfast power station which occurred while the Queen and Duke of Edinburgh were visiting the city. Within a few hours of the receipt of an urgent call, the firm had collected some hundredweights of spare parts at their works and these were taken to Woolsington Airport, Newcastle-on-Tyne, for dispatch by air to Belfast. The plane left the airport at 6 p.m. and arrived at Belfast 1½ hours later.

THE LATE COLONEL G. T. GLOVER.—The death has occurred at Brampton, Cumberland, at the age of 83, of Colonel George Tertius Glover, M.I.C.E., who retired 20 years ago from the post of chief mechanical engineer of the Great Northern Railway, Ireland. He began his career in the North British Locomotive Works, Glasgow, and later became manager of the Gateshead Locomotive Works. Subsequently, he entered the service of the Great Northern Railway, Ireland.

LANCASHIRE AND SOUTH YORKSHIRE.

THE METROPOLITAN-VICKERS WAR MEMORIAL.—A Book of Remembrance containing the names of 214 employees of the Metropolitan-Vickers Electrical Co., Ltd., who gave their lives during the 1939-45 war, has been placed in the entrance to the company's main offices at the Trafford Park Works, where it lies on an illuminated desk surmounted by a bronze sword. A page of the book will be turned every day.

EXTENDED GAS SUPPLIES.—The East Midlands Gas Board is accelerating projects for extending gas-producing plant and gasholders, designed to increase by 7,000,000 cub. ft. the supply of gas for Sheffield and Rotherham during the coming winter. The largest of the new gasholders is in Rotherham and will hold 6,000,000 cub. ft. Two smaller holders, at Killamarsh and Bakewell, are also being completed. Sheffield's maximum daily consumption of gas is over 70,000,000 cub. ft.

SHEFFIELD TRAMWAYS.—Tramway transport is going out of favour in Sheffield and it is intended, in the course of years, to replace tramways by omnibuses. The neighbouring town of Rotherham abandoned the use of tramways some few years ago. At Sheffield, the number of miles run by tramway cars has shown a decline for the past 26 years.

WORKS ANNUAL HOLIDAYS.—Sheffield industrial concerns will close on Friday, July 24, until August 4 or 5, which includes the Bank Holiday period.

THE MIDLANDS.

THE END OF THE BIRMINGHAM TRAMWAYS.—The last of the Birmingham tramcars ceased to operate on Saturday, July 4. Tramcars first appeared in Birmingham in 1873, when a short route, operated by horse-drawn vehicles, was opened between Colmore-row (then Monmouth-street), and Hockley. The track was 4 ft. 8½ in. gauge, but was converted to 3 ft. 6 in. gauge for cable haulage in 1888. Steam trams were first operated in the city in 1882. Battery electric cars were introduced in 1890 to replace the horse trams along Bristol-road, and the overhead system of electric power distribution was first used in 1901. For a year or two, horse, cable, steam and electric cars were all in use on different routes, but steam and horse trams were withdrawn in 1906, and cable trams in 1911. Extensions to the electric overhead system took place at intervals up till 1928, when the maximum route mileage of 79 was reached.

BORING FOR COAL IN RESIDENTIAL DISTRICT.—Agreement has been reached between the National Coal Board, West Midlands Division, and Wolverhampton Corporation, over the Board's proposal to sink a borehole in a residential part of the town. Permission to bore, which is intended to prove reserves of coal at the nearby Baggeridge Colliery, was originally refused by the Corporation on the grounds of interference with amenities. The agreement now reached makes provision for safeguarding the interests of the local residents. The borehole will be sunk in a playing field, not more than one-third of an acre of which is to be used, and all the machinery employed will be electrically driven.

RECLAMATION OF DERELICT LAND.—At a meeting of the Royal Sanitary Institute at Walsall, Staffordshire, on July 2, Lt.-Col. Oxenham, a Midland Regional planning officer, congratulated Walsall and other Black Country towns on the example they had set in the reclamation of derelict land. Former mining operations had left considerable waste areas; in some cases the amount was nearly a quarter of the entire area under the jurisdiction of a particular local authority. The local authorities of Bilston, Coseley, Darlaston, Dudley, Tipton, West Bromwich, Walsall, Willenhall and Wolverhampton have together reclaimed upwards of 500 acres of this hitherto useless land, which has been levelled and used for industrial sites, housing schemes and recreation centres.

IMPROVISED BOAT ENGINE.—Two Midlands firms, the Villiers Engineering Co., Ltd., Marston-road, Wolverhampton, and Charles H. Pugh, Ltd., Tilton-road, Birmingham, 9, have received news from Borneo of an interesting improvised method of boat propulsion. A missionary in British North Borneo, Mr. James Ward, had occasion to visit a tribe living on the headwaters of one of Borneo's largest rivers. The only means of access to the tribe was by water, and no motor boat had previously been tried on the rapids of this particular river. There was no motor boat available, so Mr. Ward, using an illustrated pamphlet on the Atco "Boatimpeller," made by Messrs. Pugh, as a guide, built a power unit for a 26-ft. native dug-out canoe. He adapted a Villiers Mk. 10 petrol engine of 1½ h.p., which had been used for battery charging, and mounted it on a wooden platform, arranged to swivel for steering purposes. The propeller was cut from mild-steel plate and bent to shape, and attached to a shaft and bearings taken from a crashed Auster aircraft. The canoe, with six persons and 2 cwt. of equipment aboard, travelled at about 6 knots in still water, and made a journey of about 240 miles, lasting seven weeks.

BRUSH SCHOLARSHIP AWARD FOR 1953.—A scholarship valued at 150*l*. per annum and tenable for three or four years, has been awarded by the Brush Electrical Engineering Co., Ltd., Loughborough, to Mr. D. N. Alcock, a probationary apprentice of 18. He joined the company last year.

THE LATE MR. R. A. SIDDONS.—The death has occurred, at the age of 75, of Mr. Reginald Alfred Siddons, a director of J. and J. Siddons, Ltd., iron-founders, West Bromwich, Staffordshire. Mr. Siddons was with the family firm, which was founded by his grandfather, for 54 years.

SOUTH-WEST ENGLAND AND SOUTH WALES.

GRIT NUISANCE FROM POWER STATION.—In an effort to cut down the grit nuisance at the Treforest Trading Estate, the East Wales Committee of the Welsh Board for Industry is to ask the National Coal Board if a better quality coal can be supplied to the Upper Boat power station. The electricity authority has spent 15,000*l*. on plant, since 1948, and are going to spend another 15,000*l*. in an endeavour to combat the grit nuisance.

SLUMP IN WELSH COAL EXPORTS.—The Welsh coal trade with France, which, for the second quarter of this year, was reduced to a mere 14,000 tons, compared with 160,000 tons in the first three months, will not be any better during the current period. It was announced during the past week that there is no sign yet of a resumption of normal trading and that only 14,000 tons of Welsh coal would be taken by French clients during July, August and September. A contract for 15,000 tons of Welsh coal has been negotiated with the Lisbon electricity works.

CLOSING OF TIN-PLATE WORKS.—It was reported to a recent meeting of the West Wales District Committee of the Welsh Board for Industry that most of the redundant operatives in the tin-plate industry had secured other employment. It is stated that, since the beginning of January, ten tin-plate works have closed and another five are in process of being closed. In addition, a section of the Old Castle Tinplate Works, Llanelly, has ceased production.

LAUNCHES AND TRIAL TRIPS.

S.S. "BONTEBOK."—Twin-screw suction hopper dredger, for use on the bars at the entrances to Durban and East London harbours. Built and engined by William Simons & Co., Ltd., Renfrew, for the South African Railways and Harbours Administration. Main dimensions: 330 ft. overall by 54 ft. 6 in. by 23 ft.; hopper capacity, 70,000 cub. ft., equal to 3,680 tons, can be filled in about 45 minutes. Two sets of triple-expansion surface-condensing engines. Steam for the propelling engines, pumps and auxiliary machinery is provided by four cylindrical multitubular boilers. Speed, 11 knots, fully loaded. Launch, July 1.

M.S. "MARGIT."—Single-screw cargo vessel, built by the Nakskov Shipyard, Ltd., Nakskov, Denmark, for the Myren Steamship Co., Ltd., Copenhagen. Main dimensions: 405 ft. between perpendiculars by 57 ft. 6 in. by 36 ft. 9 in. to shelter deck; cargo capacity, about 535,000 cub. ft. Six-cylinder single-acting two-stroke Diesel engine, developing 4,100 b.h.p. at 100 r.p.m., constructed by Burmeister & Wain, Ltd., Copenhagen, Denmark. Speed, 14 knots, fully loaded. Launch, July 2.

M.S. "SONATA."—Single-screw oil tanker, built and engined by Götaverken A/B, Gothenburg, for the Rederi A/B Dalen, Gothenburg, Sweden. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, 17,550 tons on a draught of 30 ft. 2½ in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Service speed, 14½ knots, fully loaded. Delivered, July 2.

M.S. "IREX."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Skibsaktieselskapet Fjeld, Bergen, Norway. Main dimensions: 460 ft. between perpendiculars by 59 ft. by 34 ft. 10 in.; deadweight capacity, about 12,000 tons on a draught of 27 ft. 6 in.; gross tonnage, 8,200. Harland-B. and W. six-cylinder single-acting four-stroke Diesel engine. Trial trip, July 8.

M.S. "THOMAS LIVESEY."—Single-screw collier, built by S. P. Austin and Son, Ltd., Sunderland, for the North Thames Gas Board, London, W.8. (Managers: Stephenson Clarke, Ltd., London, E.C.3.) Main dimensions: 257 ft. by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,700 tons on a mean summer draught of 17 ft. 1 in. Clark-Sulzer eight-cylinder single-acting two-stroke oil engine, developing about 1,280 b.h.p. at 225 r.p.m., constructed by George Clark (1938), Ltd., Sunderland. Service speed, 10½ knots. Launch July 9.

S.S. "DISPATCHER."—Single-screw vessel for carrying bauxite ore, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Pan-Ore Steamship Co., Inc. (associates of the Alcoa Steamship Co., Inc.), New York. First of two vessels for these owners. Main dimensions: 425 ft. between perpendiculars by 60 ft. by 29 ft. 6 in.; deadweight capacity, about 8,000 tons on a draught of 20 ft. 6 in. Double-reduction geared steam turbines, developing 3,300 s.h.p. at 112 r.p.m., constructed by David Rowan & Co., Ltd., Glasgow; and two Babcock and Wilcox water-tube boilers. Service speed, 12½ knots. Launch, July 9.

CONTRACT.

THE BRITISH THOMSON-HOUSTON CO., LTD., Rugby, are to supply the electrical equipment for a fast tinplate strip cold rolling mill to be installed in the new works of The Steel Company of Wales Ltd., at Velindre, near Swansea. The electrical equipment will include six direct-current motors aggregating 18,850 h.p., two 8,000-kW motor generators, and control gear of the latest type. The equipment will be employed for driving the rolling mill, which is of the five-stand type, and will have a top speed of 5,000 ft. per minute.

WAKEFIELD POWER STATION AND DISCHARGES INTO RIVER CALDER.—The Minister of Housing and Local Government has given his decision on an appeal, under Section 7 (10) of the Rivers (Prevention of Pollution) Act, 1951, which arose out of an application by the British Electricity Authority for the consent of the Yorkshire Ouse River Board to make new discharges into the River Calder from the new Wakefield power station now in course of construction. The River Board attached to their consent a number of conditions, including one limiting the heating of the river to not more than 60 deg. F. or to 2 deg. F. above the river temperature when in excess of 60 deg. F. The Authority considered this unduly restrictive and applied to the Ministry of Housing and Local Government for a determination that this condition was unreasonable. Following the holding of a local inquiry the Minister has decided that a condition shall be substituted providing that the Authority shall not heat the river to more than 90 deg. F. or to more than 20 deg. F. above the river temperature, whichever is the less.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Wood Poles for Overhead Lines.—A new specification, B.S. No. 1990, covers wood poles for overhead power and telecommunication lines. It supersedes B.S. No. 139, which dealt with red fir wood poles for telegraph and telephone lines and B.S. No. 513, which concerned European larch poles for transmission lines. The new publication specifies extra-light, light, medium and stout poles, ranging from 18 ft. to 85 ft. in height. The importance of good preservation is emphasised and this is achieved by impregnation under pressure with coal-tar creosote after the timber has been seasoned and all fabrication completed. Methods for determining the mechanical strength of stayed and unstayed poles are described in an appendix. [Price 2*s.* 6*d.*, postage included.]

Milling Cutters.—A third revision of B.S. No. 122, which is concerned with milling cutters, has now been issued as B.S. No. 122: Part 1: 1953. It constitutes the companion of Part 2 of the specification, dealing with reamers, and published last year. In Part 1 the general requirements, dimensions and tolerances for all commonly-used types of milling cutters are given, together with the diameters of arbors and standard bores, and the dimensions of keys for the arbors and the corresponding keyways. The various types of milling cutters are fully illustrated and defined, and, although it has been recognised that there are certain constructional features which it is not practicable to standardise, recommendations on some matters of detail, such as side clearance and the provision of a radius or flat, have been included. [Price 12*s.* 6*d.*, postage included.]

ABSOLUTE VISCOSITY OF WATER.

THE British Standards Institution have announced that, as from July 1, the value of 0·01002 poise for the absolute viscosity of water, at 20 deg. C., has been adopted. This new value has recently been obtained by scientists of the U.S. National Bureau of Standards employing improved means and replaces the hitherto recognised value of 0·01005 poise. The new value is being adopted in collaboration with the National Physical Laboratory and the Institute of Petroleum and coincides with its adoption in the United States by the National Bureau of Standards and the American Society for Testing Materials. Results of viscosity measurements, made by petroleum technologists and other investigators, in accordance with B.S. No. 188: 1937, a publication entitled, "Method for the Determination of Viscosity in Absolute (c.g.s.) Units," are now assumed to be based on the new value, namely 1·002 centipoises (1·0038 centistokes) and an amendment to appendix C of the specification, on the basis of the new value, has been published (reference P.D. 1655). The revised appendix C contains a table of values for kinematic and dynamic viscosities of water from 10 deg. to 60 deg. C. at 10 deg. intervals. Consequent upon the decision to use water at 20 deg. C. as the sole calibrating fluid, instead of 40 per cent. and 60 per cent. sucrose solutions of known relative viscosity, the Institution is to revise B.S. No. 188 in collaboration with the Institute of Petroleum. The publication of the amendment to appendix C of the specification is, therefore, only a temporary measure, until the revised specification is issued. Copies of the amendment, P.D. 1655, can be obtained on application to the Institution, Sales Branch, 24, Victoria-street, London, S.W.1.

NEW DELTA-WING AIRCRAFT.—It has been announced that two new delta-wing aircraft have flown recently and are expected to appear at the annual display of the Society of British Aircraft Constructors at Farnborough in September. The P.111A, constructed by Boulton Paul Aircraft, Ltd., Wolverhampton, is developed from their P.111 delta-wing aircraft and, like that aircraft, is intended for aerodynamic research. The Avro 707C, a dual-control aeroplane constructed by A. V. Roe & Co., Ltd., Greengate, Middleton, Manchester, will be used for familiarising pilots in the handling of delta-wing aircraft.

PERSONAL.

MR. J. R. EDWARDS, MR. S. J. WHEELER, MR. J. R. RIX, MR. H. J. GRAVES and MR. T. G. BRADLEY have been elected local directors of the Austin Motor Co. Ltd., Longbridge Works, Northfield, Birmingham. In addition, MR. E. BAILEY has been appointed general superintendent, South Works; MR. E. COOK, general superintendent, West Works; MR. W. EDWARDS, general superintendent, finishing shops; MR. H. HOLBECHE, superintendent, tool design and manufacture; MR. J. ODDY, general superintendent, foundry and engine production; MR. G. M. PHILLIPS, foundry superintendent; MR. G. GILL, press-shop superintendent; and MR. F. J. HADDON, night superintendent.

MR. J. NOEL WOOD, M.C., M.I.C.E., M.I.W.E., general manager, Sheffield Corporation Waterworks, has been invited to become a member of the board of the Faculty of Engineering of the University of Sheffield.

MR. K. S. PEACOCK, deputy chairman, Guest, Keen and Nettlefolds, Ltd., has been elected chairman in succession to MR. J. H. JOLLY, who is to retire, but will continue as a director of the company.

As stated on page 51, *ante*, MR. H. E. JACKSON has been re-elected President, for the year 1953-54, of the British Non-Ferrous Metals Federation, 132, Hagley-road, Birmingham, 16.

DR. H. C. MAURICE WILLIAMS, O.B.E., has been elected chairman of Council of the Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1, as from October 1.

MR. A. L. PEPPER, previously assistant to the chief officer (marine), British Railways, London, has been appointed district marine manager, British Railways, Stranraer, Wigtownshire.

MR. P. E. TRIER, M.A. (Cantab.), and MR. G. KNOTT, M.A. (Cantab.), A.M.I.E.E., have been appointed joint managers of the research laboratories of Mullard Ltd.

MR. F. N. LLOYD, chairman and managing director, F. H. Lloyd Ltd., James Bridge Steelworks, Wednesbury, Staffordshire, has joined the board of N. Hingley & Sons Ltd., Netherton Ironworks, Dudley, Worcestershire.

MR. LOUIS V. DUNLOP, manager of the Govan Shipyard of Harland and Wolff Ltd., has retired for reasons of health. He recently completed 59 years of association with the shipbuilding industry.

MR. F. H. HARRIS, B.Sc., A.C.G.I., M.I.P.E., and MR. E. H. L. COOPER, M.I.Mech.E., M.I.E.E., M.I.P.E., have been appointed joint general managers of Henry Meadows Ltd., Wolverhampton, as from July 2.

DR. NICHOLAS KEMMER, Stokes Lecturer in Mathematics in the University of Cambridge, has been appointed to the Tait Chair of Natural Philosophy, University of Edinburgh, in succession to PROFESSOR MAX BORN, M.A., Dr.phil., F.R.S., F.R.S.E., who retires at the end of the present session.

DR. K. P. HARTEN has been made director of the European Productivity Agency, which came into existence within the framework of O.E.E.C. (the Organisation for European Economic Co-operation) on May 1, 1953.

MR. W. A. PENKMAN has been made manager of the Service Division of the Marconi International Marine Communication Co., Ltd., Chelmsford, Essex.

MR. G. S. RAMAGE, secretary to the Harland Engineering Co. Ltd., B.E.P. Works, Alloa, Clackmannanshire, since 1923, has been elected to the board.

MR. ROBERT SIMPSON has retired from the position of secretary to the Workington Iron and Steel Co., Branch of the United Steel Cos. Ltd., after 51 years of service.

MR. J. JENKINS, formerly sales and service engineer with Fraser and Borthwick Ltd., Glasgow, has now joined the sales staff of the Belmos Co. Ltd., Bellshill, Lanarkshire.

MR. G. W. DUNK has been appointed sales and technical representative of Dewrance & Co. Ltd., for Southern England (Oxfordshire, Buckinghamshire, Berkshire, Middlesex, Sussex, Surrey and Hampshire) as from July 6.

THE WOODALL-DUCKHAM VERTICAL RETORT AND OVEN CONSTRUCTION CO. (1920) LTD. have changed their name to the WOODALL-DUCKHAM CONSTRUCTION CO. LTD., 63-77, Brompton-road, London, S.W.3.

SHORT BROS. AND HARLAND LTD. are opening a London design office. This will be in addition to their London headquarters at 17, Grosvenor-street, W.1, and will be in Ozonair House, Longmoore-street, Victoria, S.W.1.

BABCOCK AND WILCOX, LTD., Babcock House, Farringdon-street, London, E.C.4, announce that a new joint company in Japan, to take the place of TOYO BABCOCK K.K., namely, BABCOCK HITACHI KABUSHIKI KAISHA, has been established. The address is Tokiwabashi Office, 5, 2-Chome, Ote-machi, Chiyoda-ku, Tokyo, Japan.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, BLACKPOOL.

(For Description, see Page 85.)

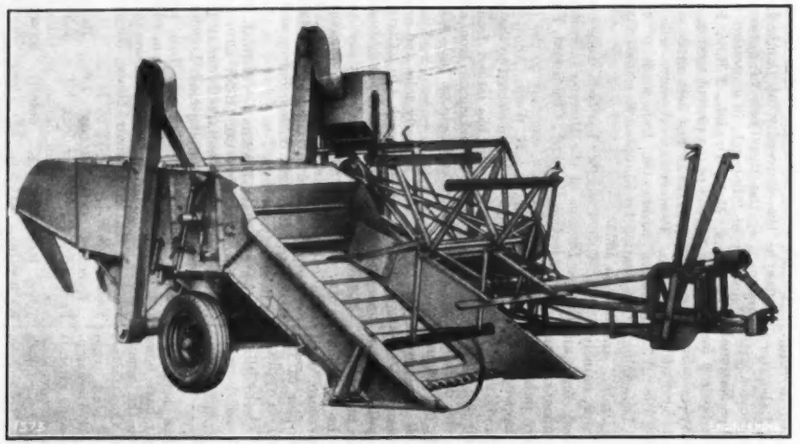


FIG. 14. TRACTOR-DRIVEN COMBINE HARVESTER; RANSOMES, SIMS & JEFFERIES, LTD.

FIG. 15. PORTABLE ELEVATOR; A. B. BLANCH & CO., LTD.

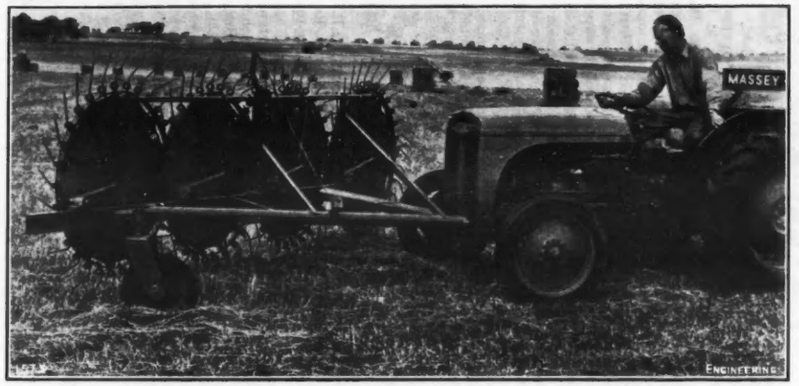


FIG. 16. FRONT-MOUNTED SIDE-DELIVERY RAKE; A. B. BLANCH & CO., LTD.

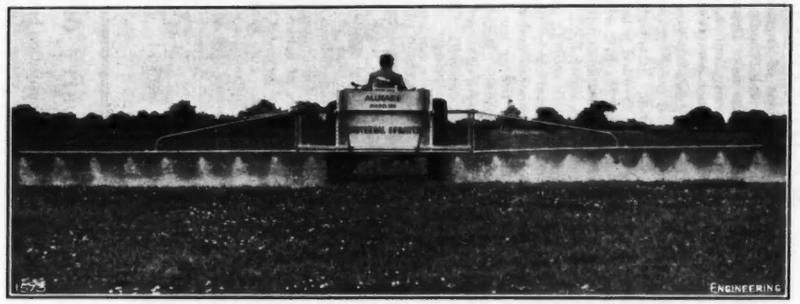


FIG. 17. UNIVERSAL SPRAYER; E. ALLMAN & CO., LTD.

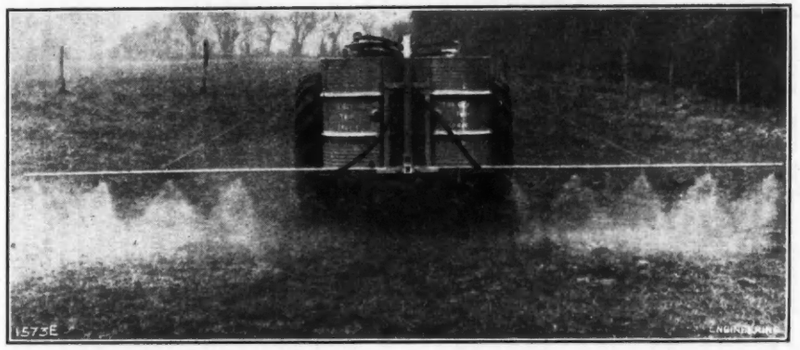


FIG. 18. TWIN-SPRAY RIG; E. ALLMAN & CO., LTD.

ENGINEERING.

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The Index to Vol. 174 of ENGINEERING (July-December, 1952) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY JULY 17, 1953.

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TELEVISION AND FREQUENCY ALLOCATION.

THE television service of this country has been much in the news lately. To begin with, the successful efforts of the British Broadcasting Corporation, which enabled thousands of viewers, both here and abroad, to participate more intimately in the Coronation ceremonies than was possible even for many of those in the Abbey itself, received a well-deserved tribute in many quarters. In fact, these efforts were a striking demonstration of what it is possible to do under existing conditions and undoubtedly accounted for the favourable reception given to Sir Ian Jacob's account of the plans that the body over which he presides have made for the future. Rather more in the background, perhaps, have been criticisms of the Government's proposals that television should cease to be a monopoly, criticisms which were strengthened by certain exhibitions of bad taste which fortuitously, if fortunately for the critics, occurred in a country where competitive television already exists. Finally, for the moment at least, the first report* of the Television Advisory Committee, which was appointed in October, 1952, to advise the Postmaster-General on the development of television and sound broadcasting at frequencies above 30 megacycles per second, was published last week and provides a factual account of the situation, both from the technically and the more controversial points of view. Before commenting on this report, it is advisable, in view of the scope of the Committee's terms of reference, to set out what they have accomplished so far. They were asked to give priority to a consideration of the development of television in the home, both by the British Broadcasting Corporation and by competitive organisations, and, in addition, to pay early attention to the best methods of introducing sound broadcasting at higher frequencies, and to consider the form of modulation which should be used and the problems which would be involved in changing over to any new system. This was a formidable task, and the Committee were wise to confine their present report to the first portion of the terms.

The frequencies with which the Committee have been concerned are those lying between 30 and 3,000 megacycles per second. This range is divided by international agreement into three very-high frequency bands—41 to 68, 87·5 to 100, and 174 to 216 megacycles—and two ultra-high frequency bands—470 to 585 and 610 to 960 megacycles; and a technical sub-committee (on which, incidentally none of the members of the main committee sat) was appointed to determine what channels could be made available in these bands. The broad conclusion reached, to use a term once familiar but now fallen into desuetude, was, not surprisingly, that the ether is congested. At first sight, however, the seriousness of the position seems to be mitigated by the fact that about 78 per cent. of the population of the United Kingdom is already provided with a television service from five high-power transmitters, and that, when five additional medium-power stations, already planned, come into operation, this figure will be increased to between 90 and 95 per cent. These ten stations, with two lower-power stations, will all make use of channels in the 41 to 68 megacycle band, which is therefore virtually fully occupied.

The band from 87·5 to 100 megacycles is regarded as being too narrow to be of much use for television, and it is proposed to reserve it for additional sound services. Part of the 174 to 216 megacycle band was allocated a few years ago to both broadcasting and services between specified fixed points, and part to aeronautical radio nevigation services. When this allocation took place, it was recognised that eight television channels could be accommodated in this band, but actually only two remain open, a state of affairs upon which Mr. C. O. Stanley comments severely in a minority report. He points out that no adequate explanation has been given of how the users mentioned came to be occupying television channels, and that no discussion took place on the onus of the financial responsibility forcing them to move. On their part, the main committee more lightheartedly recommend that this band should be cleared for television, an operation which would make it possible for 18 transmitters, using three channels, to serve about 70 per cent. of the population.

As regards the two ultra high-frequency bands, it is recommended that both should be reserved for television. On the basis of a 5-megacycle channel width, this would enable 93 channels to be provided, although, in order to ensure accommodation for a colour system, only every third channel should be utilised. A further recommendation, made for the same reasons, is that the frequencies initially used should not exceed 700 megacycles. This would provide about 50 stations. It will be seen, therefore, that to give substantial coverage of the whole country twice as many stations would be necessary as in the 174 to 216 megacycle band, so that the total transmission costs would be greater, as would probably other incidental expenses connected with adapters and aerials. In addition, the circuits, valves and other components required for both transmitters and receivers operating in these bands have not been developed to the point of large-scale production. It would be more difficult, therefore, to construct stations to operate in these bands than in the range from 174 to 216 megacycles. A further

* *First Report of the Television Advisory Committee*, 1952. London: H.M. Stationery Office. [Price 1*s.* 6*d.*]

point, which is not without importance, is that the development of television broadcasting in many countries is planned to take place in the latter band. Any arrangement which did not give a home market for receivers operating at 174 to 216 megacycles would, therefore, react unfavourably on British exports.

In dealing with certain technical matters, the committee recommend that a channel width of 5 megacycles should be employed both in the 174 to 216 megacycle and the two ultra-high frequency bands. In the first of these ranges, this might have to be increased at the expense of some loss in the maximum number of channels, if colour were introduced. In the ultra-high frequency ranges the employment of only one channel in three, as mentioned above, would leave an interval of 10 megacycles between the bands, which might later be filled if a fully "compatible" colour television system materialises. Alternatively, the interval might be occupied by only one working channel, thus leaving an effective band width of 7·5 megacycles available to each station. This would allow the transmission of colour outside each of the 5-megacycle channels used for the "black and white" signals.

Before proceeding to consider the technical aspects of frequency allocation, the Committee protect themselves by pointing out that they were told by the Post Office what frequencies are available for television and thus could make recommendations on technical grounds as to the way in which they should be used. They have no power to recommend individual allocations, nor any control over or responsibility for the provision of additional frequencies. With this proviso, they analyse the applications so far made to set up television stations in competition with the British Broadcasting Corporation. This analysis, which covers just over half the applicants—the remainder not having formulated any precise requirements—shows that a total of 23 very-high frequency and 14 ultra-high frequency channels would be required. As a result, it is estimated that at least 120 high-power stations, as well as a number of medium-power and low-power stations, involving some 50 ultra-high frequency channels, will be needed to give the desired coverage. In addition, the British Broadcasting Corporation's plan envisages the use of all eight channels in the 174-216 megacycle band; so that the scope of competitive television in this band would be severely limited if an allocation on these lines were made. In other words, a complete Broadcasting Corporation second programme and coverage of extensive areas by competitive television cannot both be accommodated in the 174-216 megacycle band. This, of course, is an issue which involves questions that go beyond purely technical aspects.

While the general conclusion to be drawn from the report is that a sufficient number of frequencies could be made available to satisfy both the British Broadcasting Corporation and the protagonists of what has come to be known as sponsored television, some doubt seems to exist upon the difficult subject of their fair allocation. There is therefore something in Mr. Stanley's contention that either the licensing authority and the industry should collaborate to prevent a recurrence of the present chaotic conditions, or that an independent body should be set up to control all frequency allocations. A further question, which will probably be considered by many to represent the reactionary point of view, is whether it is wise to expend so large a technical effort and so great a sum of money on what is mainly, if not wholly, entertainment. It is true that, in the operation of these services, much information will be gained which can profitably be used elsewhere, but whether that is the most economical way of obtaining it is open to question.

THE PROFIT MOTIVE.

A NUMBER of the large trade unions are preparing to put forward claims for further wage increases. The basic reason for this, no doubt, is that, like most other people, trade-union members would like more money than they are already getting. The ostensible reasons, however, are that wage advances are necessary because of the increasing cost of living and that they are justified by the large profits being made by industry. This latter assertion is supported by instancing certain companies not in general concerned in manufacture, who apparently pay large dividends. The explanation, probably well known to the more responsible trade-union leaders, is that the nominal capital of these companies bears little relation to the capital actually employed, the difference representing money "ploughed back" into the business. The issued capital of Imperial Chemical Industries, Limited, is 84*l.* million odd, but when reserves are added, the total is 241*l.* million. This, however, is not an example of a company apparently making very large profits. In 1951, the net dividend distributed was 5·4 per cent.

The claim that increased wages are warranted by the cost of living is based on a false and dangerous assumption. It is hardly necessary to repeat here that the maintenance of the population of this country at any reasonable standard of life now depends entirely on the volume of manufactured goods that can be sold abroad. At one time, important assistance was furnished by the sale of raw material, in the shape of coal, but there is no indication that the conditions of that time are likely to rule in any foreseeable future. In the circumstances, wage rates are an important, and even a determining, factor in the maintenance of the standard of living. Analysis of the finance of almost any engineering company will show the cost of materials as the largest item in outgoings, with wages usually in the second place; as an example, in the case of the General Electric Company, Limited, in 1951-52, materials represented 46·1 per cent. of the outgoings and wages and salaries 27·4 per cent.

As the costs of most "raw" materials, by the time that they come into the hands of the users, consist largely of wages, the actions of the craft unions have profound and extensive influence. If wages are increased and the work done in return for them is not, the only result can be rising costs, decreasing foreign sales and a falling living standard. Industry as an entity has no reserves with which to support social amenities which are not being earned. There would appear to be a formless notion in trade-union circles that such a reserve exists and it is claimed that industry is in a position to pay higher wages without increasing its selling prices. The fact that wages and salaries (salaries being a comparatively small item) represent about 25 per cent. of manufacturing costs is sufficient answer to this.

There is no objection to high wages if the output given in return is also high, and much has been heard in recent years of American productivity. It appears to have had little influence on the British working man, in whose mind the idea still persists that "capitalists" are taking more than their fair share of the profits of industry. A recent publication* quotes the case of a gathering of 3,000 black-coated and manual workers in the Midlands, a few years ago, in which, in reply to the question "who gets the biggest share" of the profits of industry, 44 per cent. replied "stockholders and management." If this fallacious idea could be eradicated it might do something towards educating the rank and file to the point of understanding that it is directly to their own interests to improve output and incidentally to increase the profits of industry.

It is becoming a relatively common practice for public companies to furnish their shareholders with detailed information about their expenses, breaking down the total income under such headings as raw materials, labour, taxes, dividend, etc. In practically every case, the last item is a very small fraction of the total. In 1951, Vauxhall Motors, Limited, out of total receipts of 31,680,000*l.*, paid only 174,900*l.* in dividends, representing 0·6 per cent. Wages and salaries amounted to 5,871,342*l.*, or 18·5 per cent., which was by far the largest item after that for materials and services such as light and power. The booklet prepared by Aims of Industry gives particulars of the outgoings of some hundred firms, a large proportion being engineering companies, and in all cases the stockholders' share is shown to be a very small part of the outgoings.

The practice of companies furnishing their shareholders with documents showing the "break-down" of their total expenditure, is more widespread in America than here, informative balance sheets, illustrated by diagrams and curves, being common. It is stated that in America such documents are distributed "not only to shareholders but to wage and salary-earners." This practice may have something to do with the more realistic attitude towards business problems taken by American labour and might be of value in this country, if there could be some assurance it would be a satisfaction to know that British workers would study the documents. Such wide distribution could not be carried out without some expense; Associated Electrical Industries, Limited, have 61,000 employees, and Vauxhall Motors, Limited, 12,000.

A Labour contention is that shareholders are taking more money from industry than formerly. If there is any truth in this, it is because of capital increases; the average dividend is certainly not greatly higher. In justice, it should be, owing to the fallen value of money and the greatly increased level of wages. This is not a matter concerning "bloated capitalists"; the holding of 90 per cent. of stockholders in Great Britain varies in value between 100*l.* and 500*l.* The attitude of organised labour in this matter is sometimes stated in some such form as that "industry should be operated in the public interest and not for private gain." Labour is an essential part of industry and there has never been any sign that wage demands are based on any other consideration than private gain. Not only common justice, but national interest, requires that shareholders should be adequately remunerated for the loan of their savings. Industry cannot flourish, can in fact hardly survive, unless it is supported by private savings, and if risk capital does not offer prospects of a more attractive dividend than do Government bonds, it will cease to be forthcoming.

There is probably something atavistic about the socialistic attitude towards "the profit motive." Interest on borrowed money was in historic times known as "usury" and was actually forbidden on religious grounds. Later, usury laws were passed limiting its amount, but permitting 10 per cent. in suitable circumstances. Some dim reflection from the old prejudices against interest appears to survive, but it is certain that community life as it is known in Great Britain could not be carried on, were interest on borrowed money forbidden. Nationalised industries and services operate with borrowed money and pay dividends which are, in effect, guaranteed by the State. For industry, with its uncertainty and risks, to be carried on it is necessary that the investor should be offered terms somewhat more attractive than those provided by Government stock; even so, the compilation made by Aims of Industry shows that his return is decidedly modest.

* *The Earnings of Industry. The Truth About Prices and Profits.* 1953 edition. Published for Aims of Industry, Limited, 12, Carteret-street, London, S.W.1, by Hollis and Carter, Limited, 25, Ashley-place, London, S.W.1. [Price 4*s.* net.]

NOTES.

THE BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION.

THE tenth anniversary of the inauguration of "Bicera"—the British Internal Combustion Engine Research Association—was celebrated on July 10 by a luncheon at Claridge's Hotel, London, W.1. The President of the Association, Lord Falmouth, took the chair, and the principal guest was Lord Woolton, Chancellor of the Duchy of Lancaster, who, as he explained in proposing the toast of "Bicera," was a substitute for the Lord President of the Council (the Marquess of Salisbury), "whose functions included the development of substitutes" and who was absent in Washington in his capacity of acting Foreign Secretary. Turning to the research activities of the Association, Lord Woolton commented on the fact that "co-operative research provides the benefits of scientific progress at very much reduced prices" and took the opportunity to draw attention to the recently-published *Sixth Annual Report of the Advisory Council on Scientific Policy* [Cmd. 8874, H.M. Stationery Office, London, W.C.2; price 6*d*. net] which, he said, "refers at the outset to the problem of the provision of scientists in this country . . . and particularly the relative use of scientists in industry in this country and in other nations which increasingly are our competitors in the industrial field." He noted that the Association had been spending 66,000*l*. a year, but considered that this was not enough—it should be nearer 100,000*l*. a year, for the country lived by the industries that it created. Lord Falmouth, in reply, agreed that expansion was desirable, but pointed out that many of the member firms had excellent research facilities of their own, so that the work of "Bicera" at Slough did not represent all the work that was in hand. He hoped that more firms would join the Association, and that some alleviation of the taxation of industry would set free more funds for industrial research and development. The only other toast, that of "The Guests," was proposed by Mr. H. N. G. Allen, M.A., M.I.Mech.E. (chairman of the Bicera Council), and acknowledged by Sir Harold Roxbee Cox, chief scientist of the Ministry of Fuel and Power.

FILM-STRIPS FOR TEACHING ELECTRICAL ENGINEERING.

The Technical Publications Department of Mullard Limited, Century House, Shaftesbury-avenue, London, W.C.2, have produced a series of 20 film-strips covering the two final years in the Ordinary National Certificate course in electrical engineering. They are intended primarily for the assistance of lecturers and teachers in technical colleges, but will also be found suitable for use in the senior science classes of grammar schools, as well as for staff and apprentice training in industrial establishments. The majority of the illustrations, which can be projected singly after the manner of lantern slides, are in the form of diagrams, graphs, etc., illustrating principles and methods of construction, but numerous photographs showing machines and apparatus under construction, as well as typical installations, are included. The simpler diagrams that can be easily and quickly drawn on a blackboard are not included, those selected being the more complicated diagrams and graphs which require a higher degree of accuracy for their representation than can be obtained by freehand drawing on a blackboard. The saving in the lecturer's time is obvious, and the students need not suffer as, we understand, photographic copies of the diagrams, etc., are available for inclusion in their lecture notes. Teaching notes are provided with each film-strip, but these notes are merely brief statements of the principles illustrated or short descriptions of the apparatus shown; no attempt has been made to impose on the lecturer any preconceived method of exposition. In producing the film-strips the Mullard Company have had the advice and assistance of an advisory panel consisting mainly of teachers in technical colleges and London polytechnics; Mr. D. Polak, B.Sc.(Tech.), of the College of Technology, Leeds, has acted as general editor of the series. Although the Mullard Company are mainly electronic engineers, the film-strips do not cover more of this specialised branch of technology than should form part of the equipment of all electrical engineers. The latter need not specialise in electronics, but those who do so will find a grounding in the general principles of electrical engineering of the utmost value. The film-strips are supplied, either singly or in complete sets, by Unicorn Head Visual Aids, Limited, Broadway Chambers, 40, The Broadway, London, S.W.1.

THE TIN RESEARCH INSTITUTE.

A feature of a tin-nickel alloy electroplating process invented about two years ago is the hardness and high resistance to tarnish of the coating produced. In the latter respect it is claimed to be equal to chromium but to have a warmer and more attractive lustre. In converting the process to industrial conditions, however, difficulties have been experienced, as the plating solution is hot and actively corrosive. Another complication is that the electrolyte must be quite free from suspended solids; hence, the success of the process depends on the discovery and adoption of a suitable filter and filtering procedure. It is stated in the report, for 1952, of the originators of the process, the Tin Research Institute, Fraser-road, Greenford, Middlesex, that a suitable filtering medium has, in fact, been found during the year covered by the report. As a result of this, the existing pilot installations have operated satisfactorily and several new plants were in course of commencing operations at the close of the year. Another alloy plating process devised by the Institute some seven years ago, in which a corrosion-resistant tin-zinc coating is deposited, has found many further applications in the radio, motor-car and aircraft industries, while the tin-copper (speculum) plating process, invented in the Institute's laboratories in 1938 and in commercial use for the past seven years, "appears to have won a permanent place in industry." Work on the new aluminium-tin bearing alloys is going forward; their extra hardness and higher fatigue strength at operating temperatures, as compared with tin-base Babbitt alloys, it is anticipated, will enable them to recapture some of the markets now held by copper-lead and other high-duty bearing alloys. Research on tin-plate has been concerned mainly with the quality of the tin deposit in both the hot-dipped and the electrolytic types of coating. A satisfactory method of producing electrolytic tin-plate in the laboratory has been adopted and this permits each of the various stages of manufacture to be closely studied.

SMOKELESS ZONES IN INDUSTRIAL CITIES.

In the course of an address delivered before the East Midlands Division of the National Smoke Abatement Society, at Leicester, on July 2, Mr. Arnold Marsh, general secretary of the Society, stated that the lethal smoke fog in London last December, causing 4,000 deaths and tens of thousands of other casualties, had led to the setting up of a new Government committee of inquiry into air pollution. A similar committee had been formed in 1920 and this had roundly condemned the existing lax measures for smoke prevention and had written its own epitaph by stating that, for many years, no Government had taken any action with the exception of appointing committees, the labours of which had had little or no result. Nowadays, however, the smoke-prevention movement had a powerful ally in fuel efficiency. Moreover, it awakened a far greater measure of public interest, and new principles of action were proving their worth. These new principles included smokeless zones and the prior approval of new fuel-burning installations. The pioneer zone in Manchester had been so successful and had received such unexpected praise that it was now proposed at least to double its area. It had been stated that if smokeless zones spread too quickly there would be a shortage of smokeless fuel, and with such difficulties the idea would fall into disrepute and the cause of smoke abatement would suffer. The answer to this was that it was just because there was not enough smokeless fuel or new smokeless appliances for the whole country that effective smoke prevention should be secured in selected areas where the benefits would be greatest, and the need most urgent. As in road safety, priority had to be given to the "black spots," and this was what was being done through smokeless zones.

FIRE RESEARCH.

The report of the Fire Research Board and of the director of the Fire Research Station for 1952 has been published for the Department of Industrial and Scientific Research and copies are obtainable from H.M. Stationery Office, London, W.C.2 (price 3*s*.; 3*s*. 1½*d*. by post). The Fire Board point out that much of the equipment at the Station is unique and that an ever-increasing demand for tests is being received from industrial concerns. The report is continued by a note on the wide range of subjects handled by the staff, who, the Board urges, should be increased forthwith. The report of the Director is divided into two parts, one part restricted to the year under review and the other to a general review of the previous six years, covering the period of existence of the present organisation. It is estimated that two out of every three fires breaking out in buildings are due to carelessness, particularly the incompetent handling of industrial as well as domestic electrical apparatus. The importance of smouldering as a cause of delayed outbreaks of fire has been investigated during the year and it has—not surprisingly—been found after much experiment and detailed statistical analysis that "draughts increased the danger from smouldering considerably, by speeding the smouldering rate"; this work has also produced, however, a great deal of experimental data of value in connection with smouldering. The factor determining the resistance of prestressed concrete to fire was found to be the temperature of the stressed cable; a concrete cover of 2½ in. over the cable was found to give a fire-resistance of two hours before a beam collapsed. In considering the growth of fires in buildings, preliminary experiments have shown that a good co-relation could be obtained between small-scale (one-fifth and one-tenth) and full-scale tests; this has enabled the work of determining the relative significance of the many factors of shape and material contributing to the rate of spread of fire to proceed more rapidly.

ROYAL SCOTTISH MUSEUM, EDINBURGH.

Two interesting exhibits in the Hall of Power of the Department of Technology of the Royal Scottish Museum, Edinburgh, are a sectioned Rolls-Royce Derwent jet aeroplane engine and a sectioned Austin A.40 motor-car chassis. These exhibits, it is stated in the report for 1952 of Dr. Douglas A. Allan, F.R.S.E., the director of the Museum, are in keeping with the policy of always having something topical and of general interest on view. Another new enterprise, commenced during the year, has been the staging of a special exhibit in the Hall of Power under the caption "Made in the Museum's Workshops." A case has been given over to a display of the results of current Museum workshop activities, in which component parts of a fine scale model of an early Caledonian Railway locomotive are to be seen with the "exquisite working finish" with which they leave the hands of the engineer craftsmen and before much of this is hidden under the painter's brush. An interesting sidelight on the arduous conditions which mechanical working models in a museum are called upon to withstand is afforded by the statement in the director's report that an automatic counter, fitted in the electric driving circuit of a model, has revealed that the operating button has been pressed no fewer than 1,000 times in a single afternoon. In the Hall of Mining and Metallurgy the work of building up a modern display of non-ferrous metals and their applications has continued. During the year under review, additional exhibits illustrating the nickel, copper and tin industries have been arranged, with the help of the industries concerned and, in par-

ticular, the Mond Nickel Company, Limited, the Copper Development Association, and the Tin Research Institute. It is pointed out that what has been done with these three metals and their alloys has only been limited by the space that can be allotted to them. During 1952, the outstanding addition to the Museum's Shipping Hall is a built-up scale model of an 18-gun brig, of the period 1800-1805, made and lent by Mr. James Gray, of Edinburgh. Two other models, one of a Colchester smack as now used in the oyster-dredging industry, and the other of a Shetland half-decked fishing boat of the 1880's, have been acquired.

LETTERS TO THE EDITOR.

PHYSICAL PROPERTIES OF STEEL AS FUNCTIONS OF THE TEMPERING TEMPERATURE.

TO THE EDITOR OF ENGINEERING.

SIR,—May I reply to the letter from Mr. G. M. Boyd, on page 821 of your issue of June 26, regarding my article on the above subject? It would appear that Mr. Boyd did not read the article very carefully. He warns against generalisation from the equations given and states that the experiments were carried out on a single sample of steel. The article makes it clear that a second steel of entirely different chemical composition was also investigated. This investigation confirmed the general conclusions obtained from the first steel.

I concur with Mr. Boyd's remarks in relation to the danger of generalisation from these two sets of tests. This point is made clear in the article itself. I quote: "Any generalisation based on these two series of tests is unjustifiable; further research is called for . . . The confirmatory results obtained are at least suggestive. They propound the probability that . . . the principal physical properties may be expressed as functions of the tempering temperature." Had Mr. Boyd read this passage I think he would have seen that his warning against generalisation was redundant.

Mr. Boyd's argument concerning the plotting of a man's weight and income against his age shows, if I am permitted to say so, very superficial thinking. Neither weight nor income can be logically regarded as directly dependent upon age but upon a combination of many other factors as well, such as health, nature of diet and employment, amount of exercise taken, economic conditions, demand for his services and just plain luck. If graphs of weight and income were plotted against age the results would certainly be a number of scattered points through which no smooth curve could be drawn and hence no mathematical analysis would be possible.

In dealing with steels the situation is entirely different. It is generally acknowledged that the physical properties of steel depend upon its structure and constituents, and that these two factors depend, in turn, upon the chemical composition of the steel and the heat treatments to which it has been subjected. It is also a well-known fact that, after hardening, the temperature at which any given steel is tempered is the controlling factor which governs its physical properties, i.e., such properties are dependent upon, or functions of, the tempering temperature. It cannot be said, by any stretch of reasoning that weight and income are in the same way functions of age.

With regard to the question of the correlation of the basic equations obtained experimentally in order to express the various physical properties in terms of one another, may I point out that mathematical analysis is an exact science, and cannot lie? Results obtained mathematically from correct data must themselves be correct. Thus, if the ultimate strength is found to be 359,000 lb. per square inch minus 315 times the tempering temperature, and the proportional limit 307,000 lb. per square inch minus 279 times the tempering temperature (Equations 1 and 2) then the ultimate strength must be 1·13 times the proportional limit plus 12,000 lb. per square inch (Equation 8) and cannot be anything else. This is irrefutable, as a very simple calculation will show, and applies to all the other equations derived from the basic ones.

I disagree with Mr. Boyd on the question of proportional limit. This was certainly not defined in the article, as such definition was deemed redundant. It is the stress at which stress and strain cease to be proportional, i.e., the point at which the stress-strain diagram diverges from the straight line (see Fig. 1). It is in no sense arbitrary but can be determined more accurately than the yield point, especially in the case of hard high-tensile steels. It is always so close to the elastic limit that the two terms are often used interchangeably.

With respect to the Izod Number, I am in agreement with Mr. Boyd. The disregard of the inherent scatter characteristics of this test is admitted as a weakness in the experimental investigations. The results of this test certainly depend, as Mr. Boyd states, upon grain size and metallurgical structure; but do not these two factors depend, in any given steel, on the heat treatments to which it has been subjected, particularly the hardening and tempering processes?

Yours faithfully,
A. A. PEEBLES.

Box 351, Bowness P.O.,
Bowness, Alta.,
Canada,
June 29, 1953.

DECENTRALISATION OF BRITISH RAILWAYS.

TO THE EDITOR OF ENGINEERING.

SIR,—It is unfortunate that Mr. Nock and I both chose to illustrate our views on this subject with reference to locomotive design, thus tending to obscure the main issues involved. I thought that it was clear from my own second paragraph that I did not join issue with you on the now-familiar arguments for or against standardisation (and you only quote those in favour). My letter was intended as a warning against the dangers of standardising at the deplorable level to which we have sunk under the administration of the Railway Executive, and of which I gave some examples. If, as you claim, our two letters are not typical of current engineering opinion, why then did you not receive a single sponanteous letter in support of the "majority" line, even from those at present responsible for carrying it out?

There is, as your readers will see for themselves, another side to many of the specific points you quote in support of your view, but space will only allow me to deal adequately with one of them. High up on your list is the reduction in money spent on locomotive repairs from 8·026 to 7·220*d.* per mile in the works and from 4·390 to 4·066*d.* per mile in the running sheds; this, you claim, is a technical development. But in his report on the Blea Moor derailment of April 18, 1952, after four years of this policy, Colonel D. McMullen, inspecting officer of railways, Ministry of Transport, "could not accept the contention" that the brake gear of the engine (the disconnection of which caused the accident) was in order. Moreover, he "considered that over a considerable period insufficient attention had been paid to examining engine brake gear" and, since this was the third serious accident within seven months attributable to a locomotive defect, found it necessary to issue a warning that "if the safety of the travelling public is to be ensured locomotives must be efficiently maintained . . .", a situation which has no parallel within recent memory under pre-nationalisation conditions.

In the face of such independent and authoritative testimony as this, do you still think that current engineering opinion would support you in commending such a "technical development"? If so, on behalf of the many who genuinely believe it vital for engineering progress, and in the public interest, to eliminate the regime responsible, with the same ruthless efficiency as they, in their turn, employed against their more successful predecessors, all I can say is: "My case rests."

Yours faithfully,
R. G. B. GWYER,
M.A., A.M.I.Mech.E., A.M.I.E.E.

The Limes,
11, Windsor-road,
Clayton Bridge,
Manchester, 10.
July 7, 1953.

OBITUARY.

MR. CHARLES LE MAISTRE, C.B.E.

WE regret to record the death of Mr. Charles le Maistre, whose work, for more than half a century, on standardisation justly brought him national and international fame. He died on July 5 at his home, Lea Gate House, Bramley, Surrey, in his eightieth year.

Charles Delacour le Maistre was born in Jersey on January 6, 1874, and was educated privately and at Brighton College. From 1892 to 1895, he was a student at the Central Technical College, South Kensington (now the City and Guilds College of which he was made a Fellow in 1929), and on finishing there he gained the Diploma of Associateship of the College in electrical engineering. For two years after that he was a pupil under Charles E. Grove in the electrical department of the Thames Ironworks; the experience he gained there included the installation of electrical equipment in ships. After his pupilage he continued in the same works, as chief assistant on electric-light and power-station work, taking charge of experimental work on electric motors for the City and South London Railway, and of electro-galvanising plant. Subsequently he was in charge of the Lithanode accumulator works, and was responsible for the installation of electrical plant in a large leather factory in south-east London. From 1900 to 1901 he supervised the dynamo-testing shop of the Thames Ironworks. After leaving that works he spent a period on the Continent.

On returning to England he took up a post as assistant to Leslie Robertson, secretary of the Engineering Standards Committee, and by this move Charles le Maistre embarked on the kind of work which was to occupy him almost until his death. He was appointed electrical assistant secretary in 1902 and served in this capacity until 1916, when he succeeded to post of secretary. The name of the Committee was changed to the British Engineering Standards Association in 1918, and when a second change was made, in 1929, to the present title (the British Standards Institution), le Maistre became the Institution's first Director. These changes of name—first from committee to association, and then from engineering affairs to an unlimited scope—mirrored the expanding ramifications of standardisation. To le Maistre belongs the credit for directing this work, and for much of its success in being adopted and copied overseas. When he retired from the Institution in 1943 (having relinquished the directorship in 1942 and spent the last year as chairman of the executive committee), he continued the work for international standardisation with which he had been prominently associated since 1904. In that year he had been made general secretary of the newly-formed International Electro-technical Commission, a post which he held until his death. Unhappily, he did not survive to participate in the jubilee celebrations of the Commission, which are to take place in Philadelphia in 1954. During the last war he took a leading part in the formation of the United Nations Standards Co-ordinating Committee, serving as secretary until it was dissolved, in 1946, to make way for the International Organisation for Standardisation.

Le Maistre was appointed a Commander of the Order of the British Empire for his services in connection with standardisation during the 1914-18 war, and he was made a Knight Commander (2nd class) of the Royal Swedish Order of Vasa. He was an honorary member of the Royal Dutch Institution of Engineers and a member of the American Institute of Electrical Engineers. He joined the Institution of Electrical Engineers as an associate in 1897, and was made an associate member two year later and a member in 1908. For a time, he served as a member of Council of the Institution. He was admitted as an associate member of the Institution of Civil Engineers in 1907. In the field of documentation he took an active interest; he was for many years a member of Council of Aslib and served as chairman in 1949-50. From 1946 to 1951 he was President of the International Federation for Documentation.

ROYAL AGRICULTURAL SHOW, BLACKPOOL.

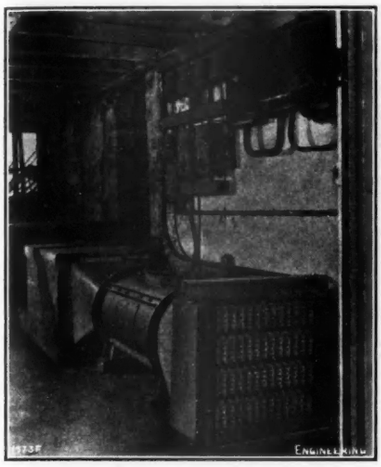


FIG. 19. IN-SILO ELECTRIC GRAIN DRYER; GENERAL ELECTRIC CO., LTD.

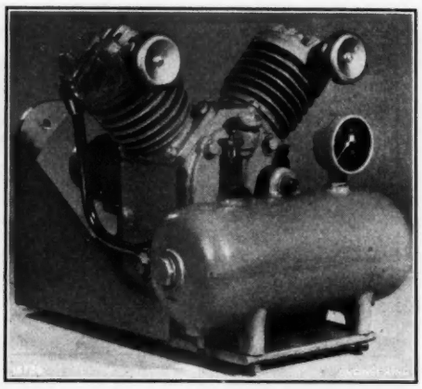


FIG. 20. TWIN-CYLINDER AIR COMPRESSOR; E. ALLMAN & CO., LTD.

THE ROYAL AGRICULTURAL SHOW, BLACKPOOL.

(*Continued from page* 45.)

TRACTOR-DRIVEN COMBINE HARVESTER.

IN the introduction to this series of reports on the Royal Show, which closed on Friday, July 10, reference was made to the evolution of the smaller types of combine harvester suitable for use by the farmer whose needs do not warrant the purchase of one of the larger self-propelled machines. A good example of such a machine is furnished by that illustrated in Fig. 14, on page 80, which was being shown by Ransomes, Sims and Jefferies, Limited, Orwell Works, Ipswich. As will be seen from the illustration, this is a tractor-driven machine, the design being such that the power required is within the capacity of the power take-off of any tractor of 25 h.p. and upwards, regardless of the working conditions. Use of the tractor power take-off to drive the machine results, of course, in a lower first cost and less maintenance and obviates the immobilisation of a valuable prime mover for most of the year.

Transmission of power to the combine is through the usual form of shaft fitted with universal joints; this drives the drum shaft, etc., through a gearbox and pulleys, facilities for changing the drum speed to suit special conditions being provided. All shafts, with the exception of that for the reel, run in ball bearings and the land wheels are fitted with taper-roller bearings. A five-bat reel is used and this is supported on one side only, horizontal adjustment being provided by a slotted quadrant; height adjustment is by means of a lever operated by the tractor driver. The cutter bar is 4 ft. wide and is operated through a Pitman arm driven by the feed-elevator shaft. The height of cut can be adjusted from 2 in. to 20 in. by means of a lever operated by the tractor driver and the cut crop is delivered into the thrashing drum by the usual form of rubberised-canvas slatted conveyor working in conjunction with a three-bladed rotor. A second rotor behind the thrashing drum controls the straw delivery to the shaker rack.

The thrashing drum is of robust construction. It is 17 in. in diameter and 41½ in. wide, and is provided with six renewable steel beaters. A lever at the side of the combine regulates adjustment of the concave away from or towards the drum and the grain is delivered to the sieves through the return pan. The shaker rack is 75 in. long and an adjustable canvas baffle is situated above the shaker so that the passage of the straw can be regulated. Grain from the shakers falls on to the return pan situated immediately below and is then delivered to the front of the chaffer sieve. Two Graepel-type moving sieves are used, namely, a chaffer sieve and a cleaning sieve, a choice of three aperture sizes being available. A four-bladed fan provides the air blast, the air being directed to each sieve through separate ducts equipped with adjustable valves. To prevent wastage of grain during the winnowing operation, the chaff is passed over a tailings grid and the grain and tailings are collected by separate augers which deliver them, in turn, to their respective elevators. The tailings, together with the loose grain that may over-run the sieves, are returned to the shakers, thus ensuring that grain wastage is reduced to a minimum. The cleaned grain is delivered to a hopper of comparatively large capacity which has two spouts equipped with hookless bag holders for bagging operations. An exceptionally roomy bagging platform is situated below, and to one side of, the hopper and a sack-discharge chute is supported from the platform. All parts within the machine that are liable to be damaged, such as the drum, cutter bar, grain and tailings elevators, etc., are protected by safety clutches incorporated in the drives to these various components.

IN-SILO ELECTRIC GRAIN DRYER.

As already mentioned, the advent of the smaller types of combine harvester and the subsequent wider use of this class of machine has necessitated the provision of means for drying the grain on the farm. Several firms have developed, and were displaying, such equipment. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, for example, were showing a selection from their range of electric platform and in-silo, or in-bin, grain-drying apparatus. A typical General Electric in-bin grain-drying unit is illustrated in Fig. 19, on this page; it consists of a duct-type air heater, a fan and the associated control gear. Although the unit is shown mounted horizontally, vertically-arranged models of the same general construction are available. Fans of the Aerofoil and propeller types, made by Messrs. Woods, of Colchester, Limited, an associate company of General Electric, are used, the former type being employed in the majority of cases. Aluminium die castings are used extensively in their construction and the design is such that the driving motors are totally enclosed, thus affording protection from damage. The Aerofoil type of fan is particularly suitable for the widely varying conditions in which farm grain-drying installations work, since they have non-overloading characteristics; variations in the resistance of the installation, therefore, will not cause overloading of the motor.

The heating elements operate at black heat and are assembled in a section of steel trunking. There is an enclosed terminal chamber and a hand-reset thermal cut-out to protect the elements in the event of the flow of air being interrupted. The load is balanced to meet the requirements of the electricity authorities, and graded stages of heat control are available. Outstanding advantages claimed for electrical dryers are: low capital cost; absence of contaminating fumes; low fire risk; and the fact that very little supervision is necessary.

PORTABLE ELEVATOR.

The introduction of combine harvesters has also led to the development of mechanical loaders for dealing with the sacks of grain deposited on the ground during harvesting operations. Several such devices were being shown, a good example being that illustrated in Fig. 15, on page 80. Known as the Stackhy, this machine, which was being shown by the manufacturers, Messrs. A. B. Blanch and Company, Limited, Crudwell, Wiltshire, is particularly suitable for loading sacks, bales and root-crops. In the illustration it is shown lifting sacks on to a trailer; the unit is designed, however, so that the drive to the conveyor mechanism can be reversed and so that the end on which, in the illustration, the sacks are being loaded can be elevated to a height of 18 ft., thus enabling it to be used subsequently for elevating the sacks directly from the trailer to the top of say, a Dutch barn, or into a loft. The conveyor position is raised and lowered by a small hand winch and, when in the raised position, it is supported by the tubular member which can be seen in the illustration just below the bed of the conveyor. When elevated to its maximum height of 18 ft., the lower end of the conveyor is 5 ft. 6 in. above the ground. It is, of course, not necessary to reverse the drive when the free end of the conveyor is raised from the ground, and the machine can, as a consequence, be used with equal facility for loading sacks of grain, etc., from a loft into a trailer situated below. The bed of the conveyor is 17 ft. long, and the width is adjustable from 7 in. to 20 in. It can be powered by almost any engine of from 1 h.p. to 1½ h.p., but the makers fit the Villiers 12 R.G. engine.

FRONT-MOUNTED SIDE-DELIVERY RAKE.

There is a tendency nowadays to use a single tractor for hauling a number of implements at the same time. In the Dominions, for example, it is not uncommon for one tractor to have behind it a harrow, a Cambridge roller, a seed drill and a flat roller, thus making it possible to carry out the operations of final preparation of the seed bed, seeding and consolidation of the drills at the same time. This practice, however, can only be employed if the power take-off of the tractor is not required to drive any other implement than the leading one. For instance, it would not be possible for a side-delivery rake to be followed by a tractor-operated baler when collecting hay or straw, or by a beet-top collector when picking up beet tops. To make this possible, however, A. B. Blanch and Company, Limited, have introduced the Blanch-Lely Mark III front-mounted side-delivery rake illustrated in Fig. 16, on page 80. This implement, which is known as the Forake, can be installed on all popular makes of tractor. The tined wheels are designed so that they obtain their drive from contact with the ground and crop; there are, therefore, no driving chains, sprockets or gears.

The tined wheels are sprung independently so that they can follow the contour of uneven or undulating ground and are lifted clear of the ground at the ends of rows by means of a single lever situated conveniently for the tractor driver. The implement is reversible, in that it can be used for turning to the right and the left, and by turning one swath at a time it can be used as a swath turner. It has been designed specifically for use with a tractor, and front attachment plates are available for most of the leading makes. These plates can be left on the tractor at all times without affecting its working and the implement is fitted in position by the insertion of a single pin. The frame is constructed from I-section and tubular-steel members and the leading end is supported at the correct height by a castor wheel fitted with a rubber tyre. It will be appreciated that working this implement in conjunction with, say, a baling machine, saves the use of a tractor; furthermore, raking and baling are carried out at the same time, an important consideration in hay making—a process so dependent on the weather.

SPRAYING MACHINERY.

The introduction of selective weed killers and greatly-improved insecticides and fungicides has led to an increased demand for efficient spraying equipment. To meet it, E. Allman and Company,

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, BLACKPOOL.

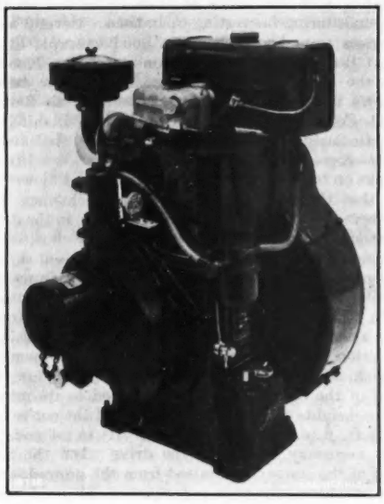


FIG. 21. AIR-COOLED DIESEL ENGINE; PETTERS, LTD.

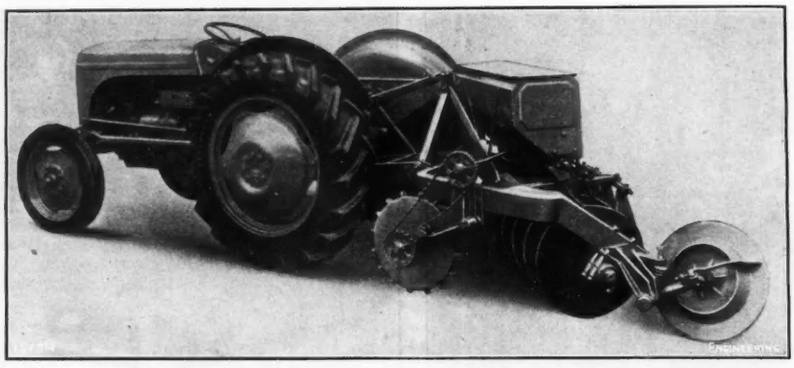


FIG. 22. COMBINED SEEDER AND CULTIVATOR; HARRY FERGUSON, LTD.

FIG. 23. TRACTOR-MOUNTED CRANE; HARRY FERGUSON, LTD.

Limited, Birdham-road, Chichester, have this year introduced two new types of sprayers, namely, their Model 100 universal sprayer and their Genimec twin-spray rig. The Model 100 universal sprayer is illustrated in Fig. 17, on page 80. It has, as its type-designation suggests, a capacity of 100 gallons and is available either for fitting to the hydraulic linkage of a standard tractor or for trailing, the illustration showing the former unit. The tank is of welded construction and is provided with a large-diameter lid to permit easy filling. It is carried by a frame constructed from angle sections, which is braced to withstand hard usage and, provided with the lifting pivots for coupling the unit to the tractor, thus leaving the tank free from all stresses. The design is arranged, however, so that a drawbar and wheels can be fitted easily to enable the machine to be converted quickly to the trailer model. The pump is driven from the tractor power take-off and has a capacity of from 25 to 30 gallons per minute with a working pressure of up to 300 lb. per square inch, the actual pressure depending on the jets in use.

The manufacturer's Genimec control system is fitted as standard equipment. This incorporates a pre-set device which ensures the pressure regulator returning to the selected pressure each time it is moved to the "on" position. When the regulator is moved to the "off" position, an automatic "suck-back" comes into operation and prevents any drip from the jets. The Genimec control system also incorporates two hydraulic agitator circulators; these are in addition to the maker's normal hydraulic agitation device, and complete mixing of all suspensions is thus assured. The spraying widths are: 20 ft., 30 ft., 48 ft. and 96 ft., the 20-ft. and 30-ft. widths being for low-volume and high-volume applications and for row-crop work; the 48-ft. and 96-ft. widths, however, are for high-volume applications only and are used, for example, in applying insecticides. To spray the 48-ft. width, the booms are removed and a single fan-shaped jet used; this is particularly suitable for spraying stagnant pools and refuse tips. The booms are folded by operation of a control at the driving position and they are provided with the usual "break-away" device to prevent damage by striking an obstacle.

"GENIMEC" TWIN-SPRAY RIG.

The Genimec twin-spray rig is illustrated in Fig. 18, on page 80. This machine has been designed specially for the export market but is available also to home buyers. The chassis is similar in design to that of the Model 100, but special attention has been paid to the attachment gear to ensure ease of fitting to the tractor, and to the control gear to give simple operation. Like the Model 100, the Genimec is available also as a trailed unit. The pump is of the maker's three-piece bronze-gear type and has a maximum working pressure of 100 lb. per square inch, the application range being from 5 gallons to 75 gallons an acre. The booms give a spraying width of 18 ft., but provision has been made for installing one of the maker's Wideangle jets which will give a spraying width of up to 48 ft. Two standard 40-gallon barrels can be installed in the cradle and the gear provided ensures proper agitation in both barrels. The barrel cradle is made from steel angle sections and is provided with parking stands.

TWIN-CYLINDER AIR COMPRESSOR.

E. Allman and Company, Limited, were also showing their single-cylinder and twin-cylinder air compressors. The single-cylinder machine is designed for coupling directly to the rear power take-off of a tractor or Land Rover; it has a displacement of 2·5 cub. ft. per minute and is particularly suitable for inflating tractor tyres and performing similar light duties. The twin-cylinder machine, which has only recently been introduced, is illustrated in Fig. 20, on page 85. Like the single-cylinder model, it has been designed for coupling to the power take-off of a standard tractor but a portable model mounted on a light two-wheeled chassis is also available. It is a single-stage air-cooled unit, the two cylinders discharging independently into an expansion chamber. The displacement is from 5 cub. ft. to 8·4 cub. ft. when operated at 450 r.p.m. and 750 r.p.m., respectively, and the pressure range is from 15 lb. per square inch to 150 lb. per square inch. It is supplied with a tractor-mounting bracket and driving coupler, and can be installed on the tractor in a few minutes.

COMBINED SEEDER AND CULTIVATOR.

The steady increase in the number of implements designed for use with tractors shows no signs of abating. The average farmer, therefore, is presented with an awkward problem, since his expenditure is limited and he is often at a loss to know how to lay out his available capital to the best advantage. There is much to be said, therefore, for dual-purpose implements, and Harry Ferguson, Limited, Coventry, are to be commended for introducing at this year's show the combined seeder and cultivator illustrated in Fig. 22, opposite. Known as the Polydisc, this machine has been designed so that, by removing the hopper

LUDWIG MOND'S LABORATORY IN 1888.

and seeding mechanism, it is converted into a cultivator. Furthermore, the machine is capable of accomplishing cultivation and seeding in one operation, an outstanding advantage in places where seasons are short and the time available for seed-bed preparation limited. When used as a cultivator, the effect on the soil is midway between that of a disc plough and a disc harrow and it is particularly suitable for such operations as stubble cleaning and summer fallowing.

Like most other Ferguson implements, it is designed for coupling to the three-point hydraulically-operated linkage fitted to the rear of their tractor. The framework is made from welded channel-section steel members and incorporates a weight box and a stand for parking. The hopper is made from rust-proofed mild-steel plate and is designed so that it is held to the main body by three linch pins for easy fitting and removal. A fluted-roller type of seeding mechanism is used. There are seven seeding units and a single seed regulator lever gives a range of seeding rates up to 12 bushels per acre. The seed falls through reinforced rubberised-canvas flexible tubes to points immediately behind the centre of the discs, thus ensuring accurate placement and good coverage. The drive for the seeding mechanism is taken from a spring-loaded detachable land-wheel, through a chain and sprocket wheels and a telescopic shaft fitted with universal joints, to a gear unit situated below the hopper. A land-wheel was chosen for driving the seeding mechanism so that the seeding rate would always be directly proportional to the forward speed of the implement. Two sizes of disc are available, namely, 22 in. in diameter and 24 in. in diameter. They are constructed from high-carbon steel and are provided with scrapers adjustable either individually or as an assembly. A furrow wheel is fitted to prevent side draught and control front-furrow width. As will be seen from the illustration, it is spring-loaded to give good penetration.

TRACTOR-MOUNTED CRANE.

Harry Ferguson, Limited, were also showing, for the first time at the Royal Show, the rear tractor-mounted crane illustrated in Fig. 23, opposite. This unit is of simple design, consisting of a telescopic steel jib of box section and a supporting framework made from tubular steel. The complete assembly is carried at the rear of the tractor, being attached by two pins to the lower links and through a special bracket to the rear casing. It is raised and lowered by means of the tractor hydraulic implement-lift assembly, and the length of the jib can be adjusted in several steps between the limits of 4 ft. 2 in. and 6 ft. 11 in. When fully extended, the maximum height of lift is 7 ft. 4 in.; when retracted, the height of lift is 5 ft. The maximum loads that can be lifted by the crane are 650 lb. with the jib retracted and 350 lb. when the jib is fully extended.

AIR-COOLED DIESEL ENGINE.

Considerable progress has been made during recent years with the development of small air-cooled Diesel engines suitable for driving elevators, hedge cutters, etc., and units with outputs as low as 1½ h.p. are now available. Messrs. Petters, Limited, Causeway Works, Staines, Middlesex, for example, were showing a new single-cylinder engine of this type which develops 1·5 h.p. at 1,000 r.p.m. and 2·5 h.p. at 1,500 r.p.m. on the 12-hour rating. This unit, the PAZ1, is illustrated in Fig. 21, opposite. It has a bore and stroke of 3 in. and is the Diesel version of the Petter PA1 petrol engine, all major parts of the two engines, with the exception of the cylinder head, cylinder and piston, being interchangeable. A direct-injection combustion system is employed, there being an offset hemispherical bowl in the crown of the aluminium-alloy piston.

The engine cylinder is cast from a special iron alloy and is provided with deep cooling fins. The cooling arrangements are similar to those employed on the PA 1 engine, the flywheel incorporating vanes which act as a blower and force the air through ducting round the cylinder head and cylinder. Overhead valves are employed, the rocker box forming part of the cylinder head. The push rods are enclosed within the cylinder wall, and both the cylinder and head are secured to the crankcase by through bolts, an arrangement that reduces distortion to a minimum.

Like the cylinder, the crankcase is machined from an iron casting; it has integrally-cast feet for base mounting and the lower part forms the sump. An H-section forged-steel connecting rod is used and this is fitted with a steel-backed copper-lead lined bearing at the big-end and a bronze bush at the little end. The main bearings are of the steel-backed whitemetal-lined type. Governing is by means of a centrifugal governor totally enclosed in the gear cover, but there is provision for small permanent changes in engine speed to be made. A Bryce fuel-injection pump is employed, this unit being situated on the top of the timing-gear cover and actuated by a cam formed on the front of the camshaft gearwheel. Spill timing is adjusted by means of shims fitted under the injection pump. With the exception of the cylinder and camshaft, which are lubricated by splash, all moving parts are supplied with oil under pressure from a plunger-type pump actuated by an eccentric on the camshaft. The drive can be taken from either end of the crankshaft, or from a shaft extension at half engine speed at the timing-gear end. A multi-plate clutch can be fitted on either the full-speed shaft or the half-speed shaft.

(To be continued.)

A DISCOVERY RECALLED.

HE who conducts research has only himself to blame if he fails to recognise a significant factor in an experiment. He who directs research, however, has a more imponderable task: has he created conditions that are favourable to his staff making discoveries? If they miss something significant, are they to blame or is he? On the other hand, if they succeed, his pleasure and delight can know no bounds. The first sign in the experiment, the recognition of its significance, the impatient call to the chief to "come and see," his warm approval, and his directions for further study—with such a pattern in the moment of discovery a dramatic element enters into the field of science.

A discovery with a pattern of this kind is recalled by a model which has been made by Mr. H. Broun-Morison for the Mond Nickel Company, Limited. The time: an evening in the year 1888. The place: a laboratory in the grounds of Dr. Ludwig Mond's house in Avenue-road, Hampstead. Experiments have been undertaken to discover why a carbon coating has developed on some nickel valves used in a plant for volatilising ammonium chloride at Mond's chemical works. Earlier investigations have suggested that carbon monoxide is responsible, and the effect of finely-divided nickel at about 350 deg. C. in bringing about the decomposition of carbon monoxide into carbon dioxide and free carbon is being studied. In the apparatus on the bench, carbon monoxide is passed slowly over finely-divided nickel in a tube, and, except when sampling for analysis, the deadly gas is allowed to burn at the exit. At the end of the day's experiments, one of Mond's collaborators turns off the furnace burners prior to shutting down the apparatus. When the tube has cooled to about 100 deg. C., the characteristic blue flame of carbon monoxide is seen to change to yellow. As the temperature falls lower the flame becomes very luminous, and when the glass tube at the exit is heated a metal mirror forms on it. That mirror is nickel. When Mond is told of this unexpected result, he comes over to the laboratory to see for himself. This is the moment portrayed in the model, as the accompanying illustration shows.

Further examination proved that the gas containing the volatilised nickel was nickel carbonyl. Experiments were then made in an attempt to obtain similar compounds of iron and cobalt, but though iron carbonyl was obtained in minute amounts, no trace of cobalt carbonyl could be detected. Some years later Mond did succeed in isolating carbonyls of cobalt, ruthenium and molybdenum, but the readiness of nickel to form a volatile carbonyl, and his initial failure to obtain cobalt carbonyl, showed Mond the way to a new process for producing pure nickel from the nickel-cobalt-copper containing ores. He set about purchasing mining properties in the Sudbury district of Canada, and in 1900 he formed the Mond Nickel Company, Limited, to refine the material. The potentialities of nickel for improving the properties of steel had been described by James Riley, a Glasgow metallurgist, in 1889. To-day, its uses are certainly more diverse than either Mond or Riley could have foreseen. The element that is used (in a non-ferrous alloy) for gas-turbine blades, is employed to give a host of metallurgical, mechanical and electrical properties. Indeed, the full significance of the experiment in Hampstead in 1888 is still being explored.

CONFERENCE ON CIVIL ENGINEERING PROBLEMS IN THE COLONIES.—Arrangements are being made by the Council of the Institution of Civil Engineers for the next biennial conference on Civil Engineering Problems in the Colonies, to be held in London from Monday, June 14, to Friday, June 18, 1954. These conferences, of which that due to be held next year will be the fourth, are intended to cater for the particular needs of members of the colonial engineering service and of others engaged on civil engineering work in the colonies. The Council would like it to be known that others besides members of the Institution may attend the conference. Persons desiring to do so, or wishing to receive further information, should communicate with the secretary of the Institution, Great George-street, Westminster, London, S.W.1.

THE BRITISH COAL UTILISATION RESEARCH ASSOCIATION.

THE annual report of the British Coal Utilisation Research Association for the year 1952, which has recently been published, shows that the Association, founded in 1938, is achieving a position of increasing importance, due to its growing membership and expanding activities. The report is available from Mr. J. B. Reed, at the Association's offices, Randalls-road, Leatherhead, Surrey (price 7*s.* 6*d.*).

During the year under review, the number of members of the Association increased from 117 to 133, and among them are manufacturers of appliances and equipment, coal producers (as represented by the Institution of Mining Engineers and the National Coal Board, the latter being the largest contributor to the finances of the Association), the exporters and factors, the producers of coke and patent fuel, and, lastly, the consumers of coal or its derivatives. In the latter category, of course, are to be found the British Electricity Authority and the British Transport Commission. The total income for the year, including a contribution of 120,000*l.* from the National Coal Board and one of approximately 77,000*l.* from the Department of Scientific and Industrial Research, was 301,881*l.*, of which the sum of 17,646*l.* remained unexpended and was allocated to reserve.

During the year, the new Domestic Appliances Research Building was substantially completed, and its formal opening, on June 24, by Sir John Charrington, vice-president of the Association, together with a description of the studies in progress, was recorded on page 20 of our issue of July 3.

An investigation into the effects of coal properties on boiler performance has been in progress for some years at the station, using a full-size Economic boiler with chain-grate stoking. These investigations show that the rank of the coal (i.e., volatile matter, coking properties and inherent moisture) when burnt on a chain-grate stoker fitted to a flue-tube boiler, had very little effect on the efficiency of the boiler; between the most and the least favourable coals, the maximum difference in boiler efficiency due to rank was barely 5 per cent., indicating that any "effect of rank is swamped by other factors." In connection with size and moisture, it has been established that with dry $\frac{3}{4}$-in. or less coal, the efficiency obtained may be only about 40 per cent., compared with about 70 per cent. using properly wetted coal. Investigations into the effects of excess air, fuel-bed thickness, burning rates and under-grate air distribution have also been carried out, together with work on grate design with a view to preventing clinker from adhering to the ignition arch in such a way as to impede the flow of fuel,

In the field of laboratory research, the main studies have been related to the effects of type of fuel and conditions of firing on the way in which heat is released from burning fuel beds, the formation and combustion of coal smoke (with particular reference to the domestic open fire) and the availability of water-tube boilers as influenced by the incidence of external deposits and corrosion. X-rays have been, and are being, employed to examine external bonded deposits, which appear to be connected with the formation of a hard, enamel-like inner layer, in which minor quantities of haematite ($\alpha - Fe_2O_3$) and mullite ($3\,Al_2O_3 . 2\,SiO_2$) have been identified, while anhydrous potassium-aluminium sulphate has been found in a predominant phase in two air-heater deposits and in the inner layer from a bonded deposit. In this connection, the report states: "The similarity in configuration of the planes of oxygen atoms in haematite and potassium-aluminium sulphate suggests that orientated crystalline overgrowths of the sulphate may occur on the surface iron-oxide layer of steel boiler-tubes, the outermost layer of which is likely, judged by the results of several recent investigations, to consist of haematite; the sulphate and the haematite might well have a common plane of oxygen atoms." This hypothesis, in explanation of the strong adhesion of these deposits to the metal, is significant, and is stated to be under further investigation.

LABOUR NOTES.

WAGE demands in the coal-mining industry appear to be likely to be deferred for the present. It should be noted, however, that they are not to be abandoned. At the conclusion of a private session, which had lasted most of the day, it was announced at the annual conference of the National Union of Mineworkers on July 7 that a motion, from the Kent area, asking for a substantial increase in wages for all miners, had been withdrawn. A second motion, sponsored by the Scottish area, requesting that the union's executive council should be instructed to press for higher wages for miners employed on a day-wage basis, to meet the rising cost of living, had been remitted to the council for consideration, without a vote being taken. About 400,000 miners would benefit from an increase in day-wage rates.

It is understood that the council had made it clear to the delegates that, before proceeding with any demand for more pay, they would carefully investigate the state of efficiency in the collieries, and the levels of costs, production, and selling prices in the coal industry. They also undertook to summon a special delegate conference when they reached a decision about the making of a wage claim. The council's investigation will be made, presumably, with the object of ascertaining what the industry can afford and to give guidance to the union as to the amount of increase which should be claimed. It is also hoped, no doubt, that the inquiry will lead to proposals for economies with which, in part, to offset the new claim. Suggestions are often made by the branches, for example, that coal is being supplied to the railways, and gas, electrical, and other industries, at too low a cost.

Pleas to the delegates for higher production, as a preliminary to demands for higher wages, were made by Mr. T. O'Brien, M.P., the chairman of the Trades Union Congress, in an address to the delegates prior to the private debate on wages. After conveying fraternal greetings from the T.U.C., Mr. O'Brien said trade unions should not abrogate their functions by neglecting to make demands for improvements in pay and working conditions, but the task confronting union negotiators was impossible if they knew that production in the industry concerned was such that improvements could not be guaranteed. Workpeople must try to raise their output to such levels as would permit proposals for better pay and conditions to be enforced, by co-operating in technical advances and in other measures for securing higher productivity.

On the same day, a motion from the Durham area asking for an investigation into the possibilities of basing piece-workers' rates on a new incentive principle, aimed at leading to higher production, was remitted to the executive council for further consideration. There was a debate on a motion that, in future, all increases in wages should become effective as from the dates on which the claims were submitted. In a reply on behalf of the council, Mr. A. Horner, the union's general secretary, stated that this matter had already been taken up with the National Coal Board. The question would not be allowed to rest until satisfaction had been obtained. A motion, from the Cumberland area, asking that the industry's conciliation machinery should be changed, so that awards by the National Reference Tribunal should no longer be final and binding, was rejected.

Warnings on the dangers of absenteeism were given by Sir Hubert Houldsworth, chairman of the National Coal Board, during the course of his address to the delegates at the session on July 8. He described absenteeism as an exceedingly disturbing development in the industry. Although another fuel crisis was threatening, fewer shifts per man had been worked during the first half of 1953 than in the corresponding period of 1952. In spite of many improvements in conditions, introduced as incentives to production, including the granting of a second week's paid holiday this year, the average number of shifts worked per man for the first 24 weeks of this year was only 115·3, against 118·4 shifts during the corresponding weeks of last year. If absenteeism in the mines continued at the present rate, the loss of production from that cause would be nearly four million tons greater than in 1952. No one could destroy the nationalised coal industry, except those who were in it, whether as administrators, management, or manual employees.

At the closing session of the conference, on July 9, the delegates dealt mainly with routine business. They also discussed, at some length, the arrangements for the welfare of mining employees, including a long composite resolution which requested, among other concessions, that there should be an immediate improvement in the weekly payments of miners receiving workmen's compensation, and that sickness and unemployment benefits should be increased. The resolution also included a number of changes designed to benefit injured and disabled miners who are not fully covered by existing schemes. With reference to all these matters, Mr. Horner gave the delegates an assurance from the council that every suggestion would receive careful consideration.

A proposal from the Midlands area that membership of the industry's supplementary pension scheme should be made compulsory was readily supported. Some time was also spent in considering the effects of pneumoconiosis, and a motion calling for intensive research into the incidence of this disease and measures likely to lead to its prevention attracted a number of speakers. Several delegates urged that statistics should be published regularly showing the numbers of those affected by industrial complaints. A motion asking for a reduction in the period of military service was lost on a card vote, after a somewhat bitter discussion.

The Government's decision to import large coal from Western Europe, which was announced on Monday, provided something of an anticlimax to the union's annual conference, with its many requests for further benefits. Mr. Geoffrey Lloyd, the Minister of Fuel and Power, told the House of Commons that this course would be taken as a means of insuring against the serious risk of a shortage of household coal during the coming winter, as existing stocks of coal suitable for domestic use were inadequate. Exports of large coal would not be cut, however. These exports, Mr. Lloyd stated, were not only valuable in themselves, but carried with them the export of considerable quantities of small coal, which is fairly plentiful.

Some 800 delegates were present at the opening session of the 15th biennial conference of the Transport and General Workers' Union at Southsea on Monday. In his presidential address, Mr. E. E. Fryer, the union's chairman, reminded the delegates that trade unionists were becoming increasingly aware of the fact that merely to increase wages, in order to meet a rise in the cost of living, did not solve anything, if the increase was almost immediately wiped out by further advances in prices. It had to be recognised that if employees were to enjoy a greater share of the nation's products, they must first develop the greatest possible measure of productivity. Of politics, Mr. Fryer said that political expediency must not be allowed to determine the action of trade unionists in the economic and industrial fields.

Concern at the continued upward trend in the cost of living was expressed at the annual conference of the National Union of Railwaymen at Paignton last week. A resolution expressing this concern and describing the Government's policy of removing food subsidies as an unwarrantable attack on living standards was carried unanimously. A continuation of such a policy, the resolution stated, depressed real wages, was not conducive to increased production, and would compel trade-union action to ease the rising burden of living costs. The conference ended on July 9.

SHEFFIELD METALLURGICAL INDUSTRIES.

FIG. 1. ELECTRIC-FURNACE MELTING SHOP.

THE METALLURGICAL INDUSTRIES OF SHEFFIELD.*

By DR. CHARLES SYKES, F.R.S.

"FIRST then be the choice of your penknife—a right Sheffield knife is best" was the advice given by a schoolmaster in 1590 and we, in this city, think this is still the best advice to-day. Sheffield has been associated with iron and steel production for centuries and an examination of its early history provides explanations for the present-day role of Sheffield as the main producing centre in the British Commonwealth and Empire of the so-called "special steels."

From 1041 onwards we find references to the cutlery industry in Sheffield. In those early days wood was probably used as fuel and the steel—cemented bar produced from iron ore—was imported from Sweden or some other country on the Continent. The local stone—millstone grit—provided excellent grinding wheels and the many streams in the neighbouring valleys provided the necessary water power. Subsequently, when the supplies of wood began to fail, adequate supplies of coal were readily available. The Company of Cutlers in Hallamshire existed as a guild long before 1624, the date when the House of Commons in the reign of James I passed the bill covering its constitution and scope. From that time onwards the Cutlers' Company has jealously guarded Sheffield's reputation for quality and protected its members' interests in the registration of trade marks.

Round about 1730, Huntsman began the production of cast steel by the crucible process. Clever use of the local clays enabled Huntsman to prepare a crucible which was sufficiently refractory to withstand steel melting temperatures and then remain sufficiently rigid to be manipulated with a charge of liquid steel. This gave a tremendous impetus to the steel trade since it yielded a much more uniform product than that produced from cemented bar, and by the end of the Eighteenth Century there was a very large trade in all types of edged tools.

The Nineteenth Century saw the traditional edged-tool business of the town being supplemented by the production of steel for what we now call general engineering purposes. This period was one of great developments in mechanical engineering: Watt developed the steam engine about 1780, and railway construction started about 1800. The limitations of cast iron and wrought iron on engineering design soon became manifest and, in addition, the behaviour of cutting tools left much to be desired. The much larger scale of engineering components required for machines of all types provided the incentive to devise larger steel-making units: the individual crucible only produced 40-50 lb., and at a relatively high price. It was also the period in which great strides were made in the evolution of all types of armament—guns, shells, armour-plate. In this atmosphere it is not surprising that major developments occurred in metallurgical processes and plant—the Bessemer process in 1856, the Siemens regenerative open-hearth furnace in 1870, Nasmyth hammers in 1850, forging presses in 1880.

The demand for improved tools and the intense rivalry between the shell and armour-plate manufacturers led to exhaustive investigations into the effect of alloying elements on steel properties and ensured that the accumulated experience gained over centuries in the production of tool steels was applied to the much larger masses of steel required for shells, guns, engineering forgings, etc. The use of manganese as a deoxidising agent was developed by Heath in 1840. In 1868 Mushet produced his self-hardening steel, the forerunner of high-speed steel as we now know it. Chromium containing alloy steel was made in 1871. Hadfield, in 1882, discovered the austenitic wear-resisting manganese steel and the silicon steel now used so extensively for electrical purposes. In 1893 the turbine casings for the Turbinia were made in Sheffield, and at the end of the century the first electric cranes became available.

During the present century, two new melting units have become available—the electric-arc furnace, 1910, and the high-frequency induction furnace, 1926—and are now widely used as they are particularly suitable for the production of refined alloy steels and tool steels. The high-frequency furnace has rendered obsolete the crucible furnace as developed from Huntsman's original furnace. In 1913 Brearley discovered stainless steel. This was first exploited in the cutlery trade but subsequent developments of the austenitic stainless steels—from 1923 onwards—now cover a very wide field.

Since the end of the 1914-18 war the relative importance of armament production has diminished. Fortunately, the increased demand from the engineering industry—particularly the motor-car and electrical industries—has more than compensated for this loss. The growth of the aircraft industry has given an additional impetus to the manufacture of high-tensile alloy steels and the discovery of steels with great resistance to scaling and high strength at elevated temperatures has kept in step with the introduction of the jet engine, the gas turbine and the continuous movement to higher operating temperatures in steam-turbine practice.

As the requirements of the engineer have become more onerous, so the methods of inspection have become more searching. Prior to the 1914-18 war, chemical analysis, Brinell testing, fracture examination, and the more common forms of mechanical tests were the main methods available for checking the soundness of products for general engineering service. Subsequent to this period, great advances in inspection and control have been introduced. Accurate temperature control, combined with a much deeper insight into the meaning of the microstructure as revealed by the optical microscope, have led to improved heat-treatment operations. Our fundamental knowledge has been increased by the use of such special equipment as the X-ray crystallographic apparatus and the electron microscope. Fatigue testing and creep testing have been introduced and applied on a large scale. Additional methods of inspection such as magnetic crack detection, radiography, using high voltage X-rays or isotopes, and supersonic testing are commonly available and have enabled standards of quality to be materially improved.

Apart from its pre-eminent position in the special steel and cutlery trades, Sheffield has an important share in the jewellery and the precious-metal trade of Britain. This industry is also a very old one. In 1743 Boulsover discovered that silver would adhere to copper and this formed the basis of a silver-plate trade in Sheffield—the famous Sheffield plate, which consisted of a copper base with a layer of silver on each surface. The introduction of electro-plating rendered the Boulsover process obsolete but there are many fine examples still extant which demonstrate the exquisite craftsmanship existing in those days. The presence of this trade in silver, nickel silver and the precious metals, allied as it is to the trade in edged tools, explains why the cutlery trade can draw not only on a long metallurgical experience but also on an unrivalled artistic background of designs, finishes, etc.

This short historical summary shows that, while in the very early years local advantages associated with fuel, water-power, and refractories may have led to the edged-tool industry being started up in the Sheffield area, the subsequent development of the steel industry in the city has been achieved by the craftsmanship displayed by the workmen engaged in the trade and by the many discoveries in metallurgy and manufacture made in the locality which were energetically exploited by the industry.

STATISTICS.

Table I shows the distribution of labour among the principal industries in Sheffield. It will be seen that though the production of iron and steel is the major employing industry, the number employed in the production of hand tools and cutlery,* together with those engaged in the jewellery, plate and refining trades, is very similar, namely, 16·3 per cent. as against 14·2 per cent. The total production of steel in the Sheffield district (including

* Address delivered during the Sheffield Summer Meeting of the Institution of Mechanical Engineers, on Wednesday, July 1, 1953. Abridged.

* By arrangement with Mr. M. A. Fiennes, whose address is given on page 57, *ante*, the machining operations on tools such as drills, saws, etc., were classed as production engineering and are not dealt with in this address.

Rotherham and Stocksbridge) in 1950, 1951 and 1952, as compared with that for the rest of Britain is given in Table III. It will be seen from Table III that the Sheffield area contributes about 14 per cent. to the total steel production of Britain, and that it includes one-third of the acid open-hearth steel and over 50 per cent. of the steel produced in electric furnaces.

Table II gives the contribution made by Sheffield and district to the production of alloy steels and indicates that it constitutes about two-thirds of the total. These figures can be broken down still further in respect of certain special products. Thus

TABLE I.—*City of Sheffield: Distribution of Labour in Principal Industries or Services (Midsummer, 1951).*

(*a*)

Industry.	Number of Insured Persons Employed.	Percentage of Total.
Iron and steel	42,858	16·3
Hand tools and cutlery	31,318	11·9
Engineering	28,644	10·9
Distributive trades	23,706	9·0
Professional services	16,738	6·4
Building and civil engineering	14,165	5·4
Food, drink and tobacco	10,657	4·1
Miscellaneous metal industries	10,150	3·9
Hotels and catering	6,872	2·6
Coal-mining	6,805	2·6
Jewellery, plate, and refining of precious metals	6,051	2·3
Local government service	5,751	2·2
Gas, electricity and water	5,292	2·0
Tramway and omnibus service	5,207	2·0
Railways	4,744	1·8
Motor vehicles and aircraft	3,136	1·2
Goods transported by road	2,550	1·0

(*b*)

—	Men.	Boys.	Women.	Girls.	Total.
All industries	166,964	8,424	77,748	9,580	262,716

Table I is reproduced by courtesy of the Ministry of Labour and National Service.

Sheffield produces 98 per cent. of the high-speed steel, 96 per cent. of the steel for tools, dies, magnets, and saw blanks, and 85 per cent. of the stainless corrosion-resisting and heat-resisting steels.

PLANT AND PRODUCTS.

Members of the Institution will be interested to know how this steel is produced and into what products it is manipulated. The following notes and illustrations are typical of equipment and products.

TABLE II.—*Alloy-Steel Production (in Thousands of Tons).*

Year.	Sheffield.	Whole Country.
1950	607	894
1951	621	969
1952	745	1,135

Melting Shops.—In a typical large basic open-hearth melting shop with an annual output of about 700,000 tons, there are 14 furnaces, each having a capacity of 85 tons, and the usual weight of ingot cast is about 4 tons. The steel is used for producing rolling ingots for billets and slabs, shell steel, tube steel, and axle blooms. Fig. 1, on page 89, shows a melting shop which produces electric steel by the arc and high-frequency processes. It has an annual output of about 100,000 tons of alloy steels, tool steels, and stainless steels. The arc furnaces, six in number, vary in capacity from 10 to 30 tons, and the high-frequency furnaces, five in number, are of capacity from 10 cwt. to 5 tons. The range of ingots regularly cast varies from 50 lb. for high-speed steel to 40 tons for special heat-resisting forgings. The size of ingot used for aircraft bars and billets lies in the range 14 cwt. to 30 cwt. For the various products made in the city, ingots varying in weight from 50 lb. for tool steel to 270 tons for heavy forgings are used, and there is a large ingot-mould industry in the district to cater for these needs.

TABLE III.—STEEL PRODUCTION (IN THOUSANDS OF TONS).

Year.	Open Hearth.		Bessemer.	Electric.	Other.	Ingots.	Castings.	Total.
	Acid.	Basic.						
Sheffield—								
1950	429	1,359	—	399	31	2,127	92	2,218
1951	442	1,236	—	428	31	2,035	101	2,136
1952	463	1,324	—	477	30	2,180	114	2,294
Whole country—								
1950	1,311	12,981	1,093	736	171	15,854	438	16,292
1951	1,259	12,277	1,103	819	178	15,154	484	15,638
1952	1,239	12,923	1,133	930	193	15,857	561	16,418

SHEFFIELD METALLURGICAL INDUSTRIES.

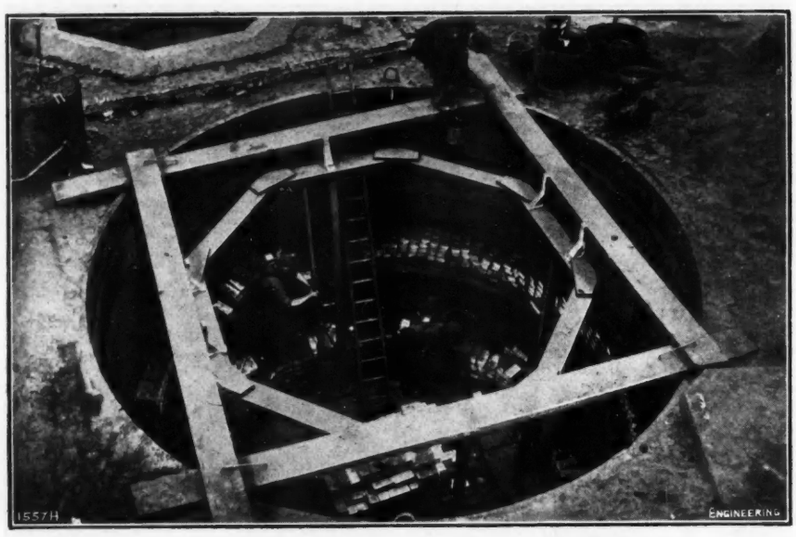


FIG. 2. PREPARATIONS FOR CASTING OF LARGE INGOT MOULD.

FIG. 3. FORGED BOILER-DRUM FINISHING SHOP.

Preparations for Casting of Large Ingot Mould (*Fig. 2, on this page*).—Roughly speaking the weight of an ingot mould is about 80 per cent. of the weight of the ingot cast in it so that considerable technical problems are involved in the production of the larger ingot moulds. In view of the wide variety of products produced from special steels—large forgings for boiler drums, alternator shafts, etc., to the smallest drill rod—the methods of manipulation used are very numerous and it is not possible to cover them all. Much of the alloy steel for the general engineering and aircraft industries is supplied in the form of rolled bars for machining, or billets for drop stamping. These are produced from the conventional cogging mills and bar mills. For forgings a variety of presses from 800 tons upwards and hammers from 10 cwt. to 25 tons are available.

Large 6,000-ton and other presses are employed for the manipulation of the very large ingots used for boiler drums, heavy forgings, etc.

Forged Boiler Drum Finishing Shop.—Fig. 3, on this page, shows the type of finishing work usually handled, namely, tube-hole drilling, standpipe fitting and welding, manhole machining, fitting, etc.

METALLURGICAL INDUSTRIES OF SHEFFIELD.

(*For Description, see Page* 89.)

FIG. 4. TURBINE WHEELS FOR JET ENGINES.

FIG. 5. TURBINE BLADES FOR JET ENGINES.

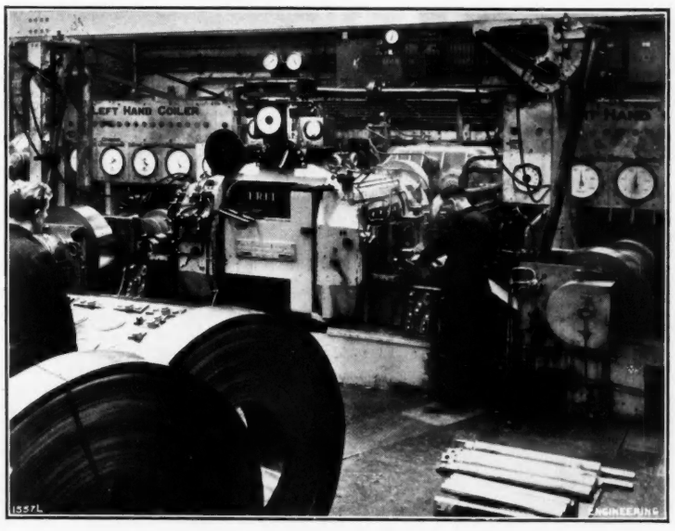


FIG. 6. SENDZIMIR MILL.

FIG. 7. "CENTRISPUN" CASTINGS.

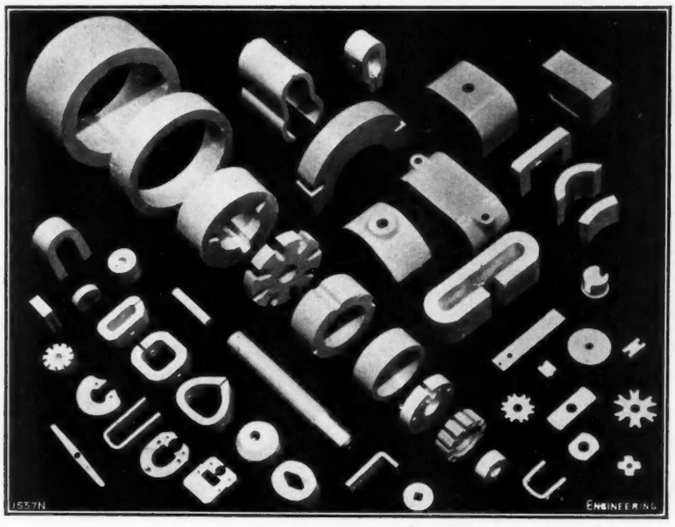


FIG. 8. PERMANENT MAGNETS.

(*To face page* 90.)

METALLURGICAL INDUSTRIES OF SHEFFIELD.

(*For Description, see Page* 89.)

FIG. 9. HARDENING OF SAW SEGMENTS.

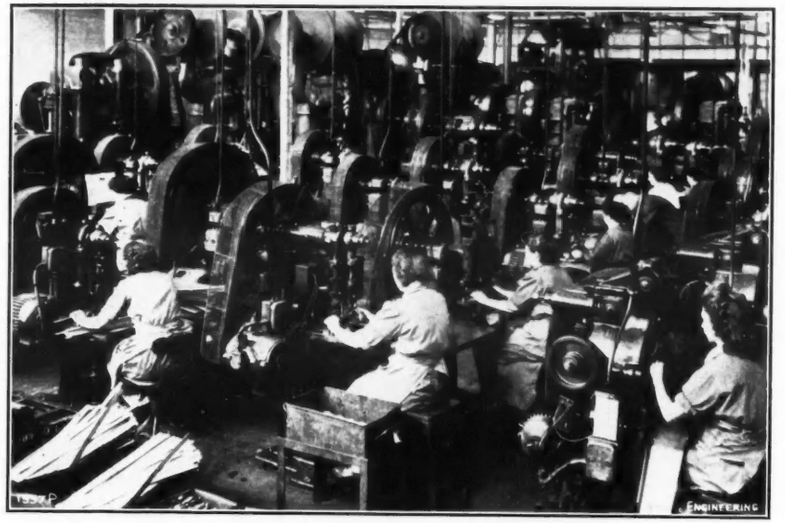


FIG. 10. PRESSING SHOP FOR CUTLERY.

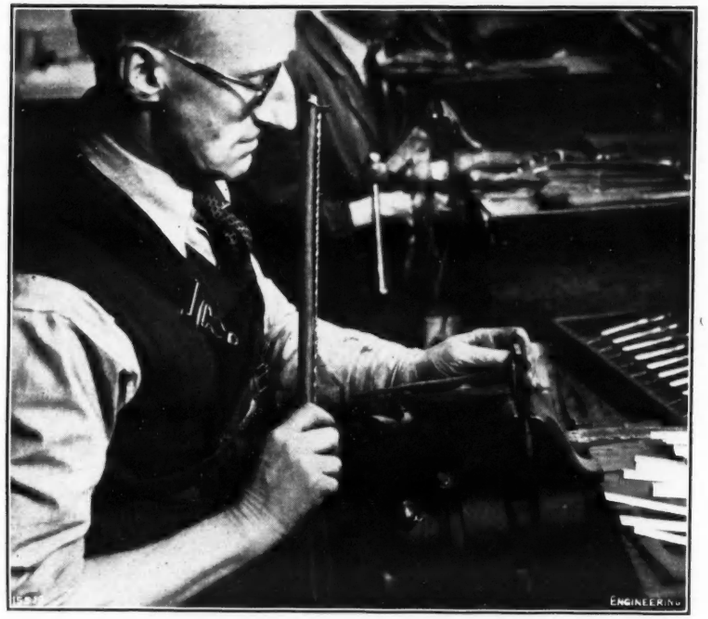


FIG. 11. BOWING OPERATION ON A PEARL SCALE.

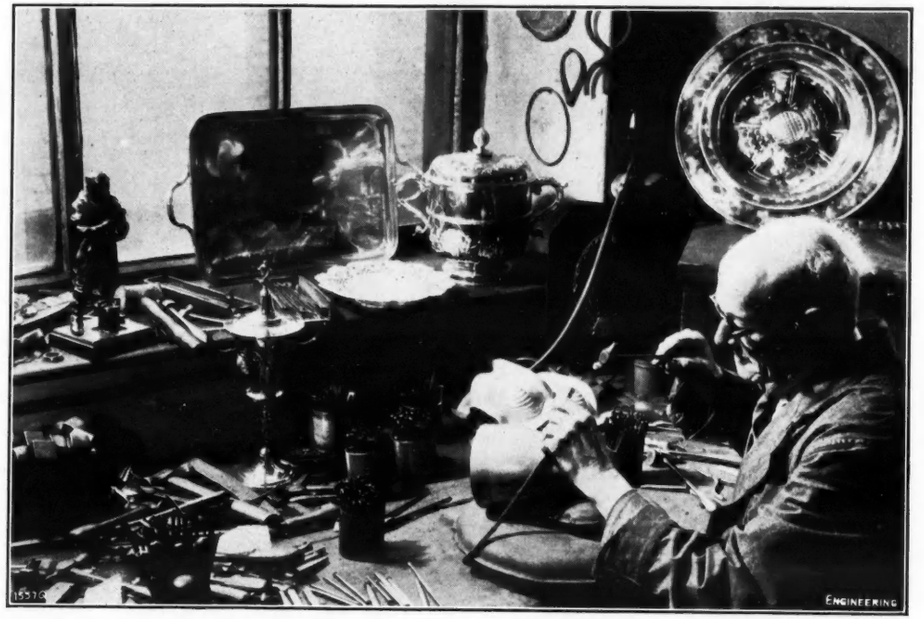


FIG. 12. THE SILVERSMITH.

(*To face page* 93.)

Sheffield produces over 70 per cent. of the really large forgings made in Britain—marine forgings, forged pressure vessels, alternators, turbine rotors, etc. Much of the acid open-hearth steel goes into such products. The largest lathes will handle forgings up to 120 ft. in length and up to 150 tons in weight. Sheffield has a major share in the production of hardened steel rolls used for the production of cold-rolled strip. The usual size of hardened steel roll for the modern strip mills is around 20 in. diameter and for the back-up rolls is about 56 in. diameter. The fully-hardened rolls, when finished, have a surface hardness of about 900 diamond-pyramid hardness, and the back-up rolls from 300 to 500 diamond-pyramid hardness.

A type of equipment used for heavy stampings for the aircraft and motor-car industries is the double-acting drop-stamp hammer. This method of production enables shapes to be made much nearer to size, thus eliminating much machining, and also gives improved grain flow which improves the behaviour under fatigue loading.

Stamped Turbine Wheels for Jet Engines (Fig. 4, Plate VII).—These wheels are produced in steels specially developed for high-temperature service. This product is probably one of the most highly stressed in engineering production, and, in view of the importance of saving in weight, the "factor of safety" incorporated in the design is low. Consequently, it is essential that the inspection processes should be most thorough. Fig. 4, Plate VII, shows wheels being submitted to the supersonic flaw-detection test.

Turbine Rotor Blades for Jet Engine.—Fig. 5, Plate VII, shows a variety of blade stampings produced primarily for jet engines and gas turbines, together with the various stages of manufacture used in making one individual blade. Here again, the soundest product possible is essential; the method of manufacture is itself a means of eliminating all but the best material. There is a large production of sheet, strip, and wire, in special steels, particularly in stainless steel, in the locality.

Sendzimir Mill.—The mill shown in Fig. 6, Plate VII, is used for cold rolling hot-rolled strip into the final product. This is a "cluster" mill and the actual work rolls of 1½ in. in diameter may be seen in the foreground. With such small rolls large reductions can be taken on thin-gauge material even if the material is in the work-hardened condition.

Castings.—There is a large business in castings made from alloy and carbon steels. Some of the largest castings made—up to 200 tons in weight—are made in Sheffield, such as press cylinders, rolling-mill housings, etc. Fig. 7, Plate VII, shows a collection of heat-resisting steel castings produced by the "centrispinning" process for use in jet engine and similar parts. This process produces a very reliable product and for rings and similar shapes offers great economies in production.

Permanent Magnet Castings.—Fig. 8, Plate VII, shows a collection of permanent magnet castings for electrical equipment, radar, etc. The illustration indicates the wide range of shapes required for the various applications. Some of the steels with the most desirable magnetic properties cannot be hot-worked or machined except by grinding and great skill has been employed in developing the necessary casting techniques for their production.

As the statistics indicate, Sheffield is still the centre of the tool- and die-steel trade. Much of this steel is still hammer forged and the craftsman—the tilter—produces, by hot forging on conventional hammers, bars of square or hexagonal section to a tolerance of $\pm\frac{1}{64}$ in. by eye. It is interesting to note that pieces of the original spiegeleisen and a portion of the first self-hardening steel ingot produced by Mushet are still preserved in Sheffield.

The quantity of steel depends not only on its chemical analysis and the skill exercised in the melting and manipulative processes, but also on the control provided during the heat-treatment operation which gives the final physical properties. This control is particularly important in the complex alloy steels and tool steels. As a measure of the attention paid to accurate temperature control, it is relevant to record that the consumption of platinum, platinum-rhodium thermocouple wire in the Sheffield district is at least as great as the amount consumed in the whole of the remainder of Britain.

Hardening of Saw Segments.—Fig. 9, Plate VIII, shows the method used for the precision production-hardening of segmental saw segments. The teeth are differentially hardened using high-frequency current, the process being controlled automatically in this instance by a photoelectric pyrometer.

Pressing Shop for Cutlery.—Fig. 10, Plate VIII, shows a modern layout used in the production of cutlery. The blanks for knife blades, as pressed from strip, can be seen in the foreground.

Bowing Operation on a Pearl Scale.—Fig. 11, Plate VIII, shows a craftsman operating a routing tool by a means of a bow. He is preparing the shield inlay in a mother-of-pearl scale. The cutler has to produce attractive finishes with such diverse materials as wood, bone, mother-of-pearl, plastic, celluloid, and precious metals, as well as with steel so that it is not surprising that many hand operations still persist.

The Silversmith.—Fig. 12, Plate VIII, shows the craftsman "chasing" decorative silverware. Unfortunately, this profession has been very badly hit by the introduction of purchase tax. This, together with the modern trend of the younger generation away from detailed painstaking work of this type has materially reduced the volume of production. One can only record the reduction in the production of this beautiful work with the greatest regret.

Acknowledgment is made to the following firms for the use of photographs: Thos. Firth and John Brown, Ltd. (Figs. 1 and 3); The Brightside Foundry and Engineering Co., Ltd. (Fig. 2); William Jessop and Sons, Ltd. (Fig. 4); Firth-Derihon Stampings, Ltd. (Fig. 5); Arthur Lee and Sons, Ltd. (Fig. 6); Firth-Vickers Stainless Steels, Ltd. (Fig. 7); Edgar Allen & Co., Ltd. (Fig. 8); Firth Brown Tools, Ltd. (Fig. 9); Richards Bros. and Sons, Ltd. (Fig. 10); G. Ibberson & Co. (Fig. 11); and James Dixon and Sons, Ltd (Fig. 12).

NUCLEAR-PARTICLE LABORATORY AT QUEEN MARY COLLEGE.

A LABORATORY that has been specially constructed and equipped for the study of nuclear particles at Queen Mary College (University of London), in Mile End-road, London, E.1, was formally inaugurated by Sir George Nelson, Chairman of the English Electric Group of Companies, on Tuesday, June 23. The ceremony was of particular interest as being the first occasion in this country at which applied nuclear physics has been officially instituted as part of the education of the undergraduate engineer. Sir George was introduced by Sir Albert Stern, Chairman of the Governors of the College, who mentioned some of his many benefactions, and, after a brief speech, Sir George declared the Laboratory open.

Mr. R. L. Fortescue, M.A., who is in charge of the work, then described the equipment and explained the aims of the Laboratory. The principal items of equipment in the main laboratory, which is below ground level, are a one-million volt impulse generator, a Van de Graaff generator, also for one million volts, a five-million volt single-impulse betatron, and an antimony-beryllium neutron source in a solution of uranium. The neutron source is located at one end of the laboratory and is enclosed in a thick shield of concrete blocks to protect the remainder of the room from radioactivity. A section of impulse accelerator tube, which can be extended, and a high-speed oscillograph for use with it, may also be mentioned as part of the equipment. In adjoining rooms there are an electron microscope and apparatus for experiments on conduction in high vacua. Radicactivity-counting apparatus is located on an upper floor.

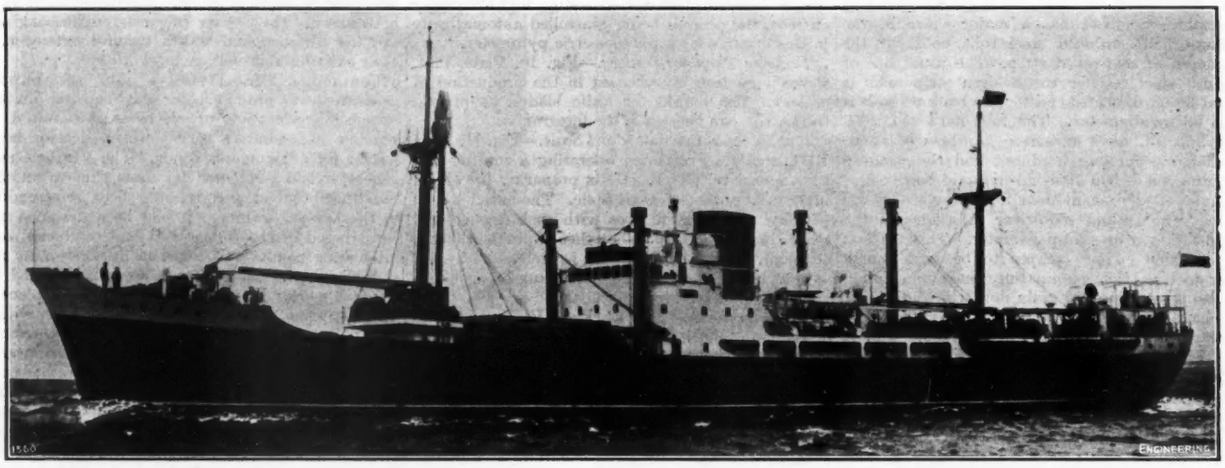
Mr. Fortescue said the Laboratory was only about half way to completion, but they had had a year's experience to draw on and were beginning to see in which direction they wanted to go. Their efforts would be divided about equally into two parts, one of which would deal with undergraduate teaching in the field of engineering physics, in particular with nuclear energy; the other would be concerned with post-graduate work in a narrower field of engineering physics, the subject chosen being insulation and conduction in high-vacuum systems. The latter field, he added, was related to nuclear energy through the design of accelerating machines. The new Laboratory would be devoted entirely to activities in the border between engineering and applied physics, and was a natural extension of their existing high-voltage laboratory.

Continuing, Mr. Fortescue said the impulse generator was intended for experiments on the impulse acceleration of electrons; it would be possible to generate a very powerful electron beam lasting for a few microseconds. The Van de Graaff generator had been used for some time in another building, but had only recently been re-assembled in the new laboratory. It had been designed and constructed in the college and had produced some interesting results and experiments on conduction at high vacua. The betatron was not intended for research work; it would serve rather as a piece of demonstration equipment. The neutron source was not on view during the opening ceremony because nothing could be seen and there was a radiation risk in going near it. It would, however, provide for two experiments in the undergraduate course in nuclear energy. The electron microscope was a commercial product, which it was hoped would assist in the examination of electrode surfaces. The counting equipment would be used for straightforward experiments in applied nuclear physics using radioactive isotopes, and would provide a useful introduction to tracer techniques as used in engineering.

To celebrate the inauguration of the Laboratory, a luncheon, which was attended by most of the guests present at the opening ceremony, was given immediately afterwards, by the Worshipful Company of Drapers, in Drapers' Hall, Throgmorton-street, E.C.2. The Master of the Drapers' Company, Mr. Frederick Charles Mason, M.C., presided and proposed the toast of Queen Mary College. In responding to this toast, Sir George Nelson expressed satisfaction that he had been selected by the Governors of the College to open the Laboratory, a circumstance which he thought was an indication of their belief that the development of nuclear physics could not stand alone but must impinge profoundly on engineering. With the provision of the laboratories they had been the first educational authority in the country to include in the normal engineering and applied science courses facilities for the study of nuclear energy at undergraduate level. Sir George went on to explain how much of the credit for the establishment of the new laboratories must go to Professor W. J. John, D.I.C., of Queen Mary College, and had arisen out of a visit he had paid to the United States in 1950, accompanied by Professor I. Evans, and sponsored by the Drapers' Company. The subject under consideration was the possible impingement of nuclear physics on electrical engineering through high-energy accelerating machines which would tie-up with the high-voltage laboratory at the College. As a result of the visit a recommendation was made to the University of London for the establishment of an appropriate laboratory at Queen Mary College, and the necessary funds for the building and equipment of the laboratory were provided by the University Grants Committee. Sir George then enumerated some of the many benefits allocated to the College by the Drapers' Company during and since the last decades of the Nineteenth Century. The total cost had been nearly a quarter of a million pounds, and was additional to the provision made by the Company for numerous scholarships and exhibitions. After referring to the possibility of power production from nuclear energy, and warning those unfamiliar with the subject not to expect too much in too short a time, the speaker made a few remarks on the subject of the co-operation between the universities and industry. Queen Mary College believed in this co-operation, which was supported by industrialists, as evidence of which he cited the high-voltage laboratory at the College, provided by his company, out of which the nuclear-particle laboratory had grown. Finally, on behalf of the Governors of the College, he thanked H.M. Government and the Drapers' Company for their interest and support.

CUNARD CARGO LINER "PAVIA."

WILLIAM HAMILTON & CO., LTD., PORT GLASGOW.



THE CUNARD CARGO LINER "PAVIA."

THOUGH the Cunard Steam-Ship Company have always been known principally as operators of passenger services on the North Atlantic, they have also maintained for very many years a small but important fleet of cargo vessels, trading from United Kingdom ports to the Mediterranean and the Black Sea. The fact that these ships have been traditionally known as the Cunard "brigs" is some indication of the long standing of these services. We illustrate above the Pavia, the first of three new ships to be built for this fleet by William Hamilton and Company, Limited, of Port Glasgow, which left Liverpool on June 1 on her maiden voyage to Gibraltar, the Piraeus and Istanbul.

The Pavia, which was laid down on September 25 last year and launched on March 19, is a vessel of the closed shelter-deck type, of 3,410 tons gross, measuring 348 ft. 3 in. in length overall and 320 ft. between perpendiculars, with a moulded breadth of 49 ft. 6 in. and a draught of 23 ft. 4 in. She is designed to carry 208,000 cub. ft. of bulk grain and 187,500 cub. ft. of baled freight, and has an insulated hold of 7,100 cub. ft. capacity. Her total deadweight carrying capacity is about 4,400 tons. No passengers are carried. The cargo spaces comprise four holds and four 'tween-deck compartments, Nos. 1 and 2 holds being forward and Nos. 3 and 4 holds aft of the machinery space. No. 1 hatch, which measures 22 ft. 6 in. long by 15 ft. wide, is served by two 5-ton derricks; No. 2 hatch, 31 ft. 6 in. long and 18 ft. wide, by two 10-ton derricks at the forward end and also by a 25-ton derrick, which is mounted on the after side of the foremast, and two 5-ton derricks at the after end; No. 3 hatch, 27 ft. by 18 ft., by two 5-ton derricks at the forward end and two of 7 tons lifting capacity each at the after end; and No. 4 hatch, 24 ft. 9 in. by 15 ft., by two 5-ton derricks. All the hatches are fitted with beams of the roller type. No. 1 hatch has a McGregor cover, and the others the ordinary wood covers. There are twelve steam winches for cargo-working, and a steam warping winch on the poop; all were supplied by Clarke, Chapman and Company, Limited, Gateshead-on-Tyne.

The propelling machinery consists of a Doxford opposed-piston oil engine, built under licence by David Rowan and Company, Limited, Glasgow, and having four cylinders 600 mm. (23⅝ in.) in diameter and a combined stroke of 2,320 mm. (91½ in.). It drives a four-bladed solid bronze propeller, designed for a service speed of 14 knots. The two scavenge pumps on the main engine are driven by levers from the rods of Nos. 1 and 2 cylinders, and the levers on No. 2 cylinder also drive a forced-lubrication pump, the fresh-water pump for circulating cooling water through the cylinder jackets and the pistons, and a pump for circulating sea water through the jacket-water cooler. The same pump also supplies circulating water to the lubricating-oil cooler. A motor-driven purifier is provided in the lubrication system. The auxiliary machinery includes two independent steam-driven pumps: one, of the Simplex type, for forced lubrication of the main engine and the other, a duplex pump, as a stand-by for the jacket and piston cooling-water service. The independent ballast pump can also be used to circulate sea water through the fresh-water and lubricating-oil coolers. The valves of the main engine have their own separate fresh-water cooling system, for which there are two pumps, one driven by steam and the other by an electric motor, either being capable of undertaking the full duty. A storage tank for distilled water supplies by gravity the two service tanks; the suctions of the engine-driven and the independent cooling-water pumps are connected to one of these tanks and the valve-cooling pump drawa from the other.

As the main engine is designed to operate on either Diesel oil or heavy fuel oil, separate gravity tanks and connections are provided for each type of fuel. The two motor-driven centrifugal fuel-oil purifiers, each of which has its own pumps, are connected to both the Diesel-oil and the heavy-oil systems. Starting air for the main engine is supplied by two compressors and is stored at a pressure of 600 lb. per square inch in two reservoirs, each of 110 cub. ft. capacity.

For electricity supply there are three steam-driven direct-current generators, situated in the engine room. Each is of 45-kW capacity, supplying current at 220 volts. The two auxiliary boilers, of the horizontal multi-tubular type, work at 120 lb. per square inch. They are designed to burn oil only, and operate normally with cold-air forced draught, but can work under natural draught if necessary. They may be used also in conjunction with a "Swirlyflo" down-flow silencer-boiler, raising steam with the exhaust gas from the main engine. The oval-section funnel contains separate uptakes from the "Swirlyflo" boiler and the two auxiliary boilers. The whistle is operated by steam. The other auxiliaries comprise separate pumps for boiler-feed, general service, ballast, bilge, sanitary, oil-fuel transfer and heavy-oil sludge purposes, a direct-contact feed heater, a distilling plant, forced-draught fan, and drain cooler.

The refrigerating machinery, supplied by J. and E. Hall, Limited, is situated in a compartment abaft the engine room, and consists of two vertical Freon compressors, each with two cylinders. They are driven by electric motors of 17½ h.p. each through multiple V-belts. The condensers are of the marine tubular type, cooled by sea water which is circulated by independent motor-driven pumps, placed in the engine room. The four insulated cargo spaces are cooled by independent cross-current coolers, designed to maintain a temperature of 0 deg. F. in one of the compartments and 10 deg. F. in the other three. Cold brine is supplied by two tubular brine evaporators, situated in an insulated room adjoining the refrigerating machinery, and is circulated by three horizontal pumps, driven by electric motors. The pumps are in the evaporator room, and the motors and starters in the refrigerating-engine room. In addition to the insulated cargo spaces, there are separate provision chambers, cooled by Freon gas grids, the gas being supplied by a separate compressor, controlled by a thermostat. There is also a refrigerated cabinet in the saloon pantry. The insulation of the cargo and provision spaces is of Fibreglass, with an aluminium lining. Distant-reading thermometers, situated in the refrigerating-engine room, provide a check on the temperatures of all the cooled spaces, which are provided with both electrically-maintained and natural ventilation.

The engineers' workshop, which is also the store, contains a back-geared screw-cutting lathe, a double-geared pillar drilling machine and a double emery-wheel grinder, all driven by belt through shafting and pulleys by a 3-h.p. electric motor. A 6-ton electric crane runs on rails, fore and aft, above the main engine.

The accommodation for the master, the chief, second and third officers, the pilot and two apprentices is on the boat deck, and the engineers are housed amidship on the upper deck, where also are the dining saloon and the wardroom. The leading ratings have their quarters in single rooms in the deckhouse above the poop, and the remainder of the crew in the poop itself, in two-berth rooms. Shower baths and washplaces, with hot and cold water, together with clothes lockers, oilskin lockers and drying rooms, are also in the poop. The crew's messrooms are in the midship house, on the upper deck, and their recreation room is in the after 'tweendeck. The galley, adjoining the messrooms, has a coal-fired range, and steam-heated boilers and ovens. The carpenter's, boatswain's and other stores are in the forecastle. The navigating, etc., equipment includes Marconi wireless and radar installations, loud-speaking telephones, a Marconi echo-sounder, and a Sperry Minor gyro-compass. There is also a fire-detecting and extinguishing system, with the indicator in the wheelhouse.

UNITED STATES TIN-PLATE.—Some 29,000 long tons of tin were consumed by the United States tin-plate industry in 1952, against 32,200 tons in 1951. About 58 per cent. was used for hot-dipped, and 42 per cent. for electrolytic, coatings.

REINFORCED-CONCRETE WORKSHOP.

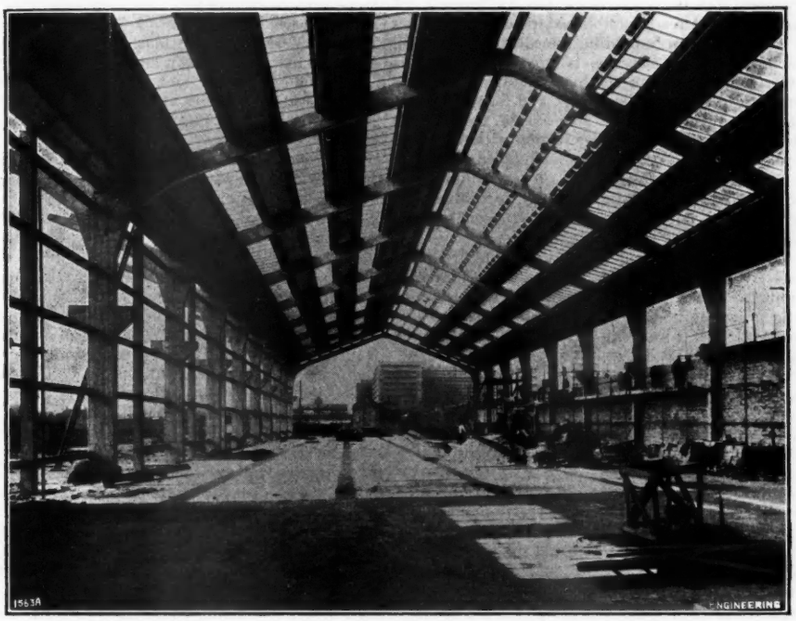


FIG. 1. WORKSHOP FRAMING.

REINFORCED-CONCRETE WORKSHOP.

THE accompanying illustrations show an example of pre-cast reinforced-concrete structural members of considerable size used for the construction of a workshop. The span of the frames, centre to centre of the posts, is 80 ft., and the posts are 27 ft. high to the top side of the rafter springing, the maximum height of the frames to the ridge of the roof being 43 ft. 3 in. The building, 300 ft. long, forms the first section of new premises for Rye-Arc, Limited, ship-repairers and boiler-makers, at their Silvertown Works, North Woolwich-road, London, E.16. Three workshops with administrative offices are to be built eventually, although only the first of these has been completed.

This building—shown during erection in Fig. 1—is a framed structure in which 13 pre-cast reinforced-concrete portal frames, at 25 ft. centres, are the principal elements; pre-cast concrete purlins and gutters span between the main frames to carry the asbestos-sheet roofing and the glazing which runs the whole length of both roof slopes. The crane beams, not in place at the time the photographs were taken, for a 10-ton crane, are carried on brackets corbelled out from the posts 16 ft. above floor level. The section of the post below the crane rail is 30 in. by 12 in. and 30 in. by 9 in. above; the rafter is 24 in. deep by 9 in. wide. To facilitate erection, the main frames were divided into three parts by joints in the rafters at zones of contra-flexure. The three pieces were then cast independently on the workshop floor and erected by bolting the scarfed joints; the purlins and gutters were also bolted into position in a similar manner. The design and erection of the portal frames was entrusted to R. E. Eagan, Limited, 1, Ashley-place, Victoria-street, London, S.W.1.

The side of the building on the right in Fig. 1 will be an exterior wall permanently, and has therefore been filled in with brickwork, but, on the other side, provision has been made for extensions by the rafter arms which already spring from the main posts and by building only a temporary asbestos cladding on intermediate concrete posts and rails. An expansion joint has been embodied between successive longitudinal members at the frame mid-way along the length of the building. The reinforced-concrete floor slab is carried on a series of ground beams spanning between groups of piles driven by the Piling and Construction Company, Limited, 111, St. James's-road, Croydon, Surrey. At one end of the shop, there are the offices for the administration of the workshop and this arrangement is to be repeated in the other bays when they are built. The general contractors for the work were H. Fairweather and Company, Limited, Hyde Works, St. James's-place, London, N.10, and the architect was Colonel R. Seifert, F.R.I.B.A.

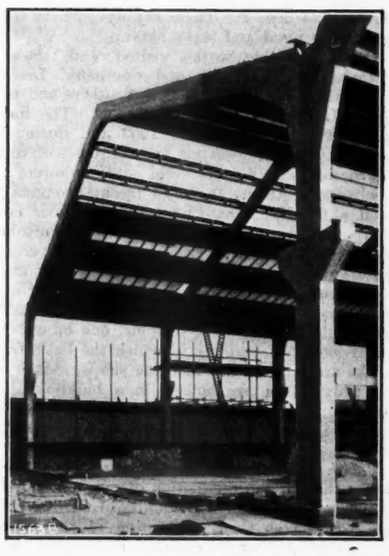


FIG. 2. PRE-CAST PORTAL FRAME.

RADIO COMMUNICATION DEVELOPMENTS IN NIGERIA.—The Nigerian Posts and Telegraphs Department is to establish a network of Marconi very high-frequency multi-channel wireless stations to connect the telephone systems of a number of towns and thus provide improved communication between Lagos and other centres. The link between Lagos and Ibadan has already been installed and those to Kaduna and Enugu and from Ibadan to Ilorin, Minna, Lokoja, Onitsha and Benin City are under construction. Repeater stations will be installed at places along these routes and will enable small local telephone exchanges to be connected into the main scheme.

SUMMER MEETING OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

As briefly recorded in last week's issue, the Summer Meeting of the Institution of Electrical Engineers took place on Tyne and Tees-sides, from Monday, June 29, to Friday, July 3, for the first time since 1927. About 300 members and their ladies attended, including the President (Colonel B. H. Leeson) and Mrs. Leeson. A summary of the visits paid to works, etc., is given below.

The meeting opened with an informal re-union at the Royal Station Hotel, Newcastle-upon-Tyne, which was attended by the Lord Mayor. On Tuesday morning, June 30, a number of alternative visits took place, some of which were repeated in the afternoon to reduce congestion. One of these was to the Heaton Works of Messrs. C. A. Parsons and Company, Limited, visitors to which assembled in the entrance hall of the new Research and Design Building. This covers an area of some 180,000 sq. ft. and embodies many novel features, among which is the radiant-heating panel which forms the ceiling. This consists of anodised aluminium, and is maintained at a temperature of 100 to 110 deg. F. by contact with a grid of steel pipes through which hot water is circulated. Pressuried air, which has been previously cleaned by electrostatic filters and can be warmed, is delivered through diffusers in the ceiling and discharged through grids below the windows. Artificial lighting is provided by no less than 12 miles of 5,000-volt cold cathode fluorescent tubes, which are designed to give a working surface illumination of up to 60 lumens per square foot. Another interesting feature is the use of paternosters for floor-to-floor transport. The entrance hall contains a memorial plaque to Sir Charles Parsons and examples of his early engineering and other activities.

Work at present passing through the turbine erecting shops includes 60-MW three-cylinder machines for the Keadby and Skelton Grange power stations of the British Electricity Authority. These are designed for a pressure of 900 lb. per square inch and a temperature of 900 deg. F. There are also a number of lower pressure machines for use in this country and overseas. In the alternator shops, where facilities are available for building and testing parts weighing up to 200 tons, work in progress includes a number of machines with outputs up to 60 MW and designed both for air and hydrogen cooling. The transformer shops are grouped side by side in three bays, the largest of which has been commissioned within the last two years. It is 400 ft. long by 80 ft. wide and is equipped to handle the largest transformers now manufactured. At the present time, three-phase units with ratings of 120 MVA are being constructed for the British Electricity Authority and are designed for operation both at 132 kV and 275 kV. Mention may also be made of three single phase units which are to be installed in the British Short Circuit Testing Station at Hebburn, and will form a th ree-phase bank for switchgear testing at 275 kV and an impulse level of 1,250 kV.

Another party visited the works of A. Reyrolle and Company, Limited, at Hebburn, Co. Durham. This factory, which was opened in 1901, now covers about 45 acres on both sides of the Newcastle-South Shields Railway. An inspection was first made of an alternating-current network analyser, which has been installed for the study of power system problems. Although mainly of conventional design, it contains a number of novel features, among which mention may be made of an automatic mimic diagram and check metering arrangements. The base frequency is 1,592 cycles per second, which is, of course, higher than usual and will allow such high-frequency phenomena as the rate of rise of restriking voltage to be studied. In the works, demonstrations were given of the opening and closing of two air-blast circuit breakers, one with a rating of 3,500 MVA at 132 kV and the other with a rating of 7,500 MVA at 275 kV. Great interest was taken in the design and arrangements of these units. A number of small-oil-volume circuit-breakers with ratings up to 5,000 MVA at 220 kV were also on view, their operating principles

being demonstrated by a sectioned single phase of a 132-kV unit. The general principles of the firm's horizontal draw-out metal-clad switchgear were demonstrated on a direct hand-operated 11-kV panel with a rating of 150 MVA. Examples of flameproof switchgear for use in mines, which has always been a major activity of the company, were on view.

A visit was also paid to the electric cable factory of Messrs. W. T. Henley's Telegraph Works Company, Limited, at Birtley. This was officially opened as recently as 1950, and, as will have been gathered from the description of its equipment which we gave at the time,* is laid out in a manner which is a definite departure from cable-making factory traditions. It has an area of about 400,000 sq. ft., and its output consists of rubber and plastic insulated cables. Generally speaking, the machines are individually driven, the total installed capacity being about 4,500 kVA, which is obtained from the North Eastern Electricity Board's mains. Low-voltage distribution is by paper-insulated cables, which are laid in ducts to distribution pillars and thence by rubber-insulated cables to distribution boards, a system which facilitates alterations and extensions. Electric heating is used for such processes as annealing, tinning and lead covering.

The Lemington glass works of the General Electric Company, which were also visited, were acquired by the firm in 1906 to render them independent of the Continent for the supply of lamp bulbs. Since that time hundreds of millions of both lamp and radio-valve bulbs have been produced, and, although development in mechanical production has taken the bulk of the business to other parts of the country, a great variety of special shapes and colours are still being made. More recently, television tubes have been produced by both machine and manual methods, and glass refractors for street and aerodrome lighting are also manufactured.

The mine at Havannah, which was visited by another party, is of drift construction and thus forms a contrast to the more familiar deep-shaft mines. The drifts, which are 15 ft. by 9 ft. 6 in. in cross-section, are being driven through boulder clay, and are lined with steel arches and reinforced concrete slabs in the coal measure strata. The main drift will contain an electrically-driven cable-belt conveyor with a capacity of 300 tons per hour, which will be 1,815 yards long and have a lift of 663 ft. Other parties inspected the Neptune shipyard of Swan, Hunter, and Wigham Richardson, Limited, and the tobacco factory of W. D. and H. O. Wills, which is equipped with modern air-conditioning plant and an automatically-controlled heating system, while the less technically-minded were given an opportunity of viewing the Roman camps at Corstopitum and Borcovicus, or enjoying a trip down the River Tyne.

In the evening, an excursion was made by coach to Durham Castle, where a dinner-dance was given.

A similar number of alternative visits were also paid on Wednesday, July 1. These included inspections of the works of Imperial Chemical Industries, Limited, at Billingham and Wilton. The former occupies a site of about 1,000 acres on the north bank of the River Tees and employs some 15,000 people. It is not surprising, therefore, that only a small part of it could be seen in the course of a short visit. Its products range from fertilisers to high-grade petrol, most of which are made from seven well-known indigenous raw materials—air, water, coal, anhydrite, creosote, benzene and common salt—supplies of which are conveniently obtainable. Since at Billingham steam is a chemical raw material, as well as a source of power, the boilers may be considered as the basis of all the factory processes. High-pressure steam is produced mainly at 800 lb. per square inch in 16 units, and is used to supply 65 MW of electrical generating plant. It is then passed at a pressure of 275 lb. per square inch to compressors, blowers and other heavy machinery, and finally used at a still lower pressure for various chemical processes. In addition, a coke-oven plant with a throughput of over 1,000 tons a day produces the gas from which the nitrogen and hydrogen required for ammonia synthesis and hydrogenation are made.

* See ENGINEERING, vol. 170, page 375 (1950).

The site at Wilton is being developed with the intention of providing the company with room for the development of any of their ten manufacturing divisions. It is being developed in stages, the manufactures already established including a number of synthetic and moulding powders, and an oil cracker in which ethylene is produced. Plant is under construction for the manufacture of the new synthetic polymer "Terylene," and for spinning it into continuous filament and staple fibres. The site is supplied from a power station with a present capacity of 60 MW,* which was designed primarily to provide steam for chemical processes and space heating, but the adoption of high pressures has enabled electricity to be generated economically as a by-product.

A visit was also paid to the Cleveland Iron and Steel Works of Dorman, Long and Company, Limited. These are the largest of the Dorman Long group of works and their coke-ovens, blast-furnaces, steel furnaces, and rolling mills cover about 670 acres. They are of historic interest, since it was here that Sydney Gilchrist Thomas was provided with facilities for his experiments on the manufacture of basic Bessemer steel. The coke-oven plant comprises two batteries of 68 underjet compound regenerative ovens and there are three blast-furnace plants with a total of ten stacks, including two, with an output of 600 to 700 tons a week each, for the manufacture of ferro-manganese. There are two steel plants each with weekly outputs of 7,000 to 8,000 tons of ingots and the rolling mills, which are mainly electrically driven, are engaged in the production of rails and various other sections. Steam for power production is obtained from five boilers, which are fired with either blast-furnace and coke-oven gas and/or coal and coke breeze and have an output of 100,000 lb. of steam per hour at a pressure of 450 lb. per square inch and a temperature of 725 deg. F. These supply both electrical generating plant and turbo-blowers.

Other Tees-side works visited were those of Richardsons, Westgarth and Company, Limited, at Hartlepool, and of Siemens Brothers and Company, Limited, at West Hartlepool. The former works were established in 1903 and during the last few years the output has consisted of turbo-alternators, condensers and turbo-blowers for steelworks. Among the most recent products has been a 60-MW, 3,000-r.p.m. three-cylinder cross-compound turbo-alternator for the Portobello Station of the British Electricity Authority. The factory of Siemens Brothers and Company, Limited, was opened in 1946 for the manufacture of automatic telephone-exchange equipment. It consists essentially of four main sections, one of which is a self-contained building in which the basic frame works are fabricated. Machine shops, switch and assembly shops, are housed in a building about 800 ft. long by 250 ft. wide, while switch and sub-assembly shops and wiring shops are separately accommodated.

Those interested in the supply of electricity rather than in the production of raw material and its utilisation had the opportunity of visiting either the North Tees C power station of the British Electricity Authority or the Herrington Burn substation of the North Eastern Electricity Board. The former, when completed, will house four 60-MW three-cylinder turbines, which will be supplied with steam from 360,000-lb. pulverised-fuel fired boilers at a pressure of 950 lb. per square inch and a temperature of 940 deg. F. These turbines will be coupled to hydrogen-cooled alternators, which will generate at 11 kV and will be connected to transformers in which the voltage will be stepped up to 66 kV.

The Hetherington Burn substation is situated at about the centre of the eastern half of the Durham coalfield and mainly supplies a colliery load. It is of the outdoor type and in layout and equipment is typical of 24 others in the area, which are supplied by some 500 miles of 66-kV feeders, mainly overhead lines, and in turn feed into the 20-kV, 11-kV and 6-kV networks. The 66-kV bus-bars form two separate ring mains, which can be coupled by an interconnector. Small-oil-volume switchgear with a rating of 1,500 MVA is installed and controls the feeder, transformer and other circuits. There are four 15-MVA 66/20-kV transformers with on-load tap-changing gear and two 46-MVA 66-kV auto-transformers, which are similarly equipped and are used for load sharing and voltage control. The 20-kV switchgear, which has a rating of 350 MVA, is installed in four houses. The loading of all the 66-kV feeders and of some of the 20-kV feeders and the positions of all the 60-kV and 20-kV switches are indicated to the control engineer at Newcastle; the 66-kV regulators and tap changers can be operated, the 66-kV switches tripped, and the 20-kV switches both closed or tripped from the same points.

* See ENGINEERING, vol. 174, page 330 (1952).

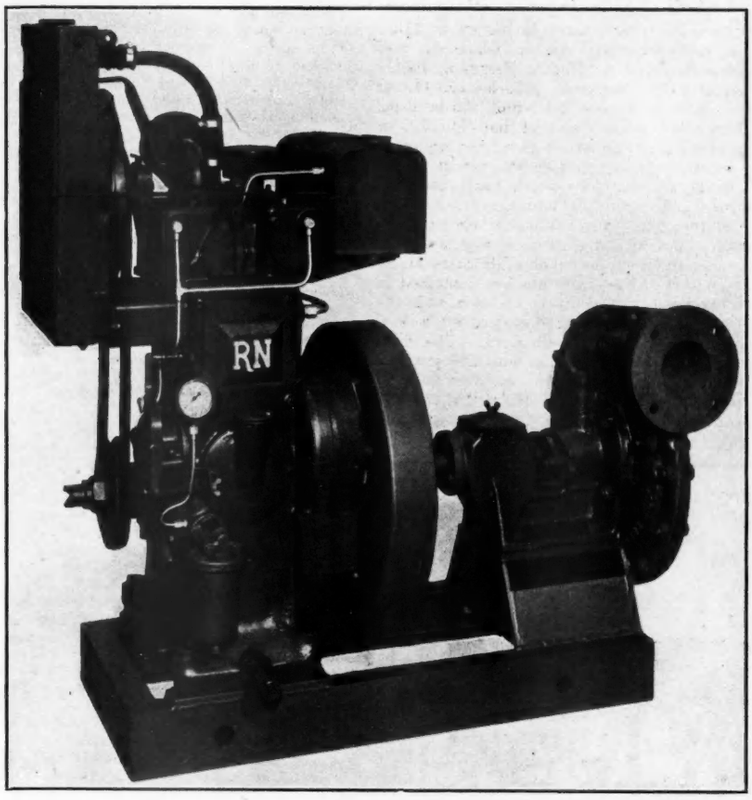
The technical visits on Thursday, July 2, included inspections of the Dunston "B" power stations and the Stella North and Stella South power stations of the North Eastern Division of the British Electricity Authority. The former station, which was commissioned in 1933, has a present installed capacity of 300 MW and a full description of its equipment and the operating results obtained were recently given in ENGINEERING.* The steam-raising plant consists of both stoker and pulverised-fuel fired boilers, the two latest units with their reheaters being associated with only one turbine. Dunston was the first power station in this country to adopt this unit principle with a reheat cycle on a large scale. The steam conditions are 600 lb. per square inch and either 800 deg. or 850 deg. F., with reheat of the exhaust from the high-pressure cylinders. The four older turbines are two-cylinder tandem sets and run at 1,500 r.p.m., while the others are three-cylinder sets running at 3,000 r.p.m. The generator voltages are 13·5 kV and 11 kV, which are stepped up to 66 kV in solidly-connected transformers.

The two power stations known as Stella North and Stella South are being built on opposite banks of the River Tyne, some three miles upstream from Dunston. The equipment at Stella North will consist of four pulverised-fuel fired suspended type water-tube boilers, each of which will supply 550,000 lb. of steam per hour at a pressure of 900 lb. per square inch and a temperature of 900 deg. F. Each boiler will be supplied from four Raymond bowl mills with a maximum capacity of 25,200 lb. of coal per hour, three of which will be sufficient to maintain the maximum continuous output. Firing will be effected through 16 tilting burners arranged in tiers of four in each corner. They will be provided with a gas by-pass damper, which will act as a secondary control for the primary superheater. The walls of the combustion chamber will consist of bare tangent tubes. The economisers will be of the plain-tube type and two regenerative air heaters and two electrostatic precipitators are being provided for each unit. The turbines, one of which will be supplied from each boiler, will be of the three-cylinder reaction type and will drive 60-MW hydrogen-cooled alternators generating three-phase current at 11·8 kV. They will exhaust to a three-pass condenser which will be supplied with cooling water at the rate of 38,000 gallons per minute. Four concrete towers will be erected for cooling purposes and the condensate will be passed through a drain cooler, two low-pressure steam heaters, a direct-contact de-aerator heater and two high-pressure steam heaters, the final feed-water temperature being 385 deg. F. Stella South will be of similar design, but will contain five boilers and the same number of hydrogen-cooled turbo-alternators; direct river cooling will, however, be used. Both stations will be connected to the 132-kV grid through their own switching stations and subsequently to the 275-kV grid through a substation at Stella West. The stations are expected to be commissioned in 1955, and to be completed in 1957.

Other visits on Thursday morning included one to the electrically-operated Lynemouth Colliery, which is now being reconstructed by sinking the two original shafts a further 225 ft. to a new winding level, the widening of the 15-ft. diameter shaft to 18 ft. and the driving of a network of drifts below the lowest seam. Improved mine cars and haulage facilities will be provided, with power loading of the cars into the cages. Each shaft will also be

* See ENGINEERING, vol. 174, page 802 (1952).

8-H.P. DIESEL ENGINE AND CENTRIFUGAL PUMP.



equipped with a 1,225-h.p. automatic winder raising one 4½-ton car per wind to the surface.

An inspection was also made of the works of Pyrotenax, Limited, at Hebburn, where mineral-insulated copper-covered cables have been produced since 1937. The manufacturing process consists of compressing magnesium-oxide powder into round blocks which are placed inside long copper tubes of about 2 in. internal diameter. Up to seven copper core rods are then inserted through pre-formed holes in the blocks and the assembly is subjected to a series of cold-drawing and annealing operations until the required size is obtained.

Another visit was paid to Harton Colliery, which was opened as long ago as 1844, but is now completely electrified, the motors installed having an aggregate horse-power of about 9,000, which are almost equally divided between surface and underground. The equipment includes a winder which is driven by a 1,100-h.p. motor and raises 4¼ tons of coal during each winding cycle of 90 seconds.

On Thursday afternoon, the Victoria Works of Clarke, Chapman and Company, Limited, at Gateshead, were open to inspection, and visitors had an opportunity of seeing the iron and brass foundries, the former having an average output of 150 tons of cleaned castings a week and supplying all the firm's requirements. The other foundry produces all types of non-ferrous castings from those weighing a few ounces up to 2 tons. Work in progress includes steel structures and high-pressure water-tube drums for power-station boilers. Steam, electric and hydraulic deck machinery and auxiliaries form a predominant part of the ouput of the machine and fitting shops. The performance of these was illustrated by a demonstration of the firm's group drive for cargo winches, which are intended for ships with an alternating current supply. In this case, two 5-ton winches were supplied from a dual output generator which was driven by a squirrel-cage motor. The dual-output generator differs from the normal Ward-Leonard generator in that it can supply the two winch motors independently and simultaneously. The two generators are therefore combined in one unit which is similar to an ordinary four-pole machine with a standard armature and single commutator, but with two pairs of brushes which provide power independently to the winch motors.

Another party visited the works of the Bushing Company, Limited, at Hebburn, Co. Durham, which was established in 1929 for the manufacture of condensing bushing insulators for the grid. At present, the greater proportion of the output comprises bushings of hard synthetic resin-bonded paper, but oil-impregnated dry paper bushings and oil-filled barrier bushings are also manufactured, the voltage range in all cases being from 11 to 300 kV.

An extension of the factory, now nearing completion, will more than double the present floor space, and has been laid out to ensure a unidirectional flow of work. A new high-tension laboratory is also in course of construction and, when completed, will have four testing areas, the maximum voltages in which will be 700 kV, 350 kV, 150 kV and 80 kV. Each area will be equipped with a Schering bridge for power-factor measurements and with a discharge bridge, as well as with the usual measuring instruments. In addition, an impulse generator, with a maximum peak voltage of 1,200 kV, will be provided, as well as equipment for heavy-current heating tests on bushings.

In the evening a dinner-dance was given at the Old Assembly Rooms, Newcastle-on-Tyne, and on Friday, July 3, whole-day excursions were made to Kielder Forest and the Border country, as well as to the Roman camps.

LYNMOUTH HARBOUR IMPROVEMENTS.—Approval has been given by the Ministry of Housing and Local Government, in principle, to work being commenced on the second part of the Lynmouth Harbour reconstruction plan. This part of the scheme includes the dredging of the harbour and the rebuilding of the causeway, and will enable pleasure steamers once more to embark and discharge their passengers. Work on the former section of the programme, which is now well in hand, covers the rebuilding of the Rhenish Tower and the harbour arm.

8-H.P. DIESEL ENGINE

THE small Diesel engine shown in the accompanying illustration, coupled to a centrifugal pump, has been introduced recently by Russell, Newbery and Company, Limited, Dagenham, Essex. For about four years, prototype models of the engine have been undergoing tests during which, we are informed, one has made over four hundred million revolutions. The engine, which is known as the "Husky," will develop 5 h.p. at 1,000 r.p.m. and 8 h.p. at 1,500 r.p.m., and is rated in accordance with British Standard Specification No. 649. The stroke is 4¼ in. and the bore 3·75 in., giving a cylinder volume of 49·7 cub. in.; the compression ratio is 17·5 : 1. The mean effective pressure at 1,000 r.p.m. is 80 lb. per square inch, and the engine operates on a four-stroke cycle. It is claimed to be easy to start and quiet when running, and is designed to meet all the requirements for a small prime mover. In particular it is said to be suitable for use with contractors' plant, agricultural machinery and electric generators; it is also in demand overseas for irrigation purposes.

It incorporates the Russell-Newbery patented combustion chamber and their special design of piston-head. The piston-head is conical in shape and from a point near the apex of the cone a cylindrical plug shape nose projects. The cylinder-head is shaped to match the piston-head, and the plug, when the piston is at top-dead-centre, enters a bored throat of similar dimensions which leads to a combustion chamber set at a tangent to it. Slots cut at the side of the throat assist in creating turbulence. The valves are placed at right-angles to the axis of the piston and are slightly offset to bring them to the centre of the combustion chamber; and the fuel injection nozzle is on the side opposite the throat. During the compression stroke the charge of air is forced through the tangential throat at the top of the cylinder and given a rapid swirl and at the moment of injection the plug on the piston enters the throat and in combination with the cut-away slots creates a controlled turbulence and produces complete combustion of the fuel without detonation. It is claimed that this arrangement prolongs the life of the working parts, the even heat flow from the apex of the piston reducing the tendency of the rings to stick, and resulting in the minimum cylinder wear. Tests of 8,000 hours duration on a four-cylinder engine using this type of piston showed a liner wear at the top of the stroke of 0·00075 in. for every 1,000 hours of running.

Unified screw threads have been used throughout the engine in accordance with the latest recommended practice. The cylinder-head and crankcase are of cast iron, and the piston of an aluminium alloy. The valves are push-rod operated and arranged horizontally; they can be removed without detaching the cylinder-head or adjacent piping. The lower portion of the crankcase incorporates a sump, and one of the main-bearing housings is made detachable to allow the crankshaft to be withdrawn. The main-bearings are lined with white metal.

The fuel equipment is of the C.A.V. type and the pintle nozzle has a large, self-cleaning type, of orifice. The governor is driven from the end of the camshaft and is arranged to control the engine speed in accordance with the British Standard requirements; an externally fitted speeder spring enables the speed to be adjusted. The fuel tank is mounted above the engine, as shown in the illustration, and supplies the fuel pump through a filter. The engine may be water cooled from a header tank or a radiator and when a fan is employed with the radiator a deduction of one-third h.p. must be made from the performance figure.

Starting is by a hand-crank and to reduce the effort required a decompression lever connected to the inlet valve is mounted on the cylinder head. The engine can be arranged with the power take-off shaft at either end giving the same r.p.m. as the crankshaft and one or two flywheels can be fitted as required. A reduction drive is also incorporated which will enable a power take-off running at half the engine revolutions per minute to be fitted at the gearbox end.

NOTES ON NEW BOOKS.

Treibstoffe für Verbrennungsmotoren.

By DR. ING. FRANZ SPAUSTA. Second edition, Springer Verlag, Mölkerbastei 5, Vienna, Austria. [Price 77*s.* 6*d.*]

THIS book is the first of two volumes constituting the second edition of a work originally published under the same title in 1939. Much technical progress has since been made in the manufacture and application of natural and synthetic liquid fuels, and in this new edition the author has included descriptions of many recent advances and of processes at present employed in liquid-fuel production. In view of the mass of additional information, the work has been divided into two volumes dealing, in volume 1, with the manufacture and properties of liquid fuels, and in volume 2, with the ignition and knock characteristics. The first volume comprises eight chapters on the manufacture of liquid fuels from crude oil, natural gas, lignites anthracite and oil shale, and through the Fischer-Tropsch, hydrogination and polymerisation processes. A further six chapters are devoted to benzene, the high-pressure extraction of oil from anthracite, by the Pott and Broche and the Uhde processes, and the manufacture and properties of ethyl alcohol, methyl alcohol and other alcohols. In the final chapter the author discusses the main features of modern Diesel engines, and the properties required of the fuels used with each particular type. Each chapter contains a historical review and is complete with numerous diagrams, charts and data tables. A comprehensive bibliography of the subject matter is appended. The author traces the progress of the exploitation of Scottish shale from the first plans prepared in 1781 by Lord Dundold to 1913, when the annual output of oil shale reached a total of 3,000,000 tons. The available deposits of oil shale in Scotland were then estimated at 500 million tons. The author has avoided frequent recourse to mathematical, chemical and other highly technical terms and forms of presentation. This book may therefore be strongly recommended to everyone engaged in the production or application of liquid fuels.

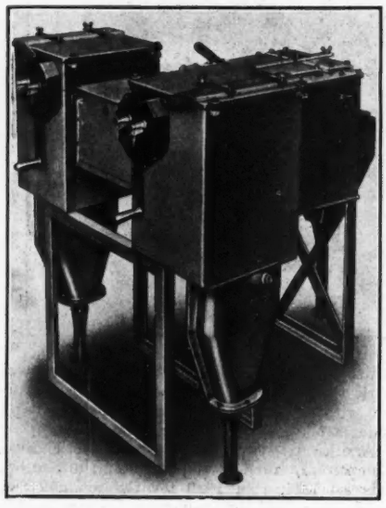
La Traction Electrique et Diesel Electrique.

By P. PATIN. Editions Léon Eyrolles, 61 Boulevard Saint Germain, Paris, (5e). [Price 2,500 francs.]

THIS work is one of a series on various aspects of French railway administration, operation and equipment, and is hardly likely to be the least important of the series, either in subject matter or in treatment. Readers of ENGINEERING will be aware in general terms of the progress that has been made with various forms of electric traction in France, but this book provides an additional mass of useful technical information, which can only be compared with that presented to the convention on this subject which was organised by the Institution of Electrical Engineers in 1950. It begins with a chapter on general principles, in which such matters as tractive effort, adhesion, and slipping, and their influence on the design of rolling stock, are dealt with. The various systems of electric traction are then briefly described, after which there are two long and detailed sections dealing respectively with the design of the mechanical parts of direct-current locomotives and their electrical equipment. In these, the author draws fully on the wide experience which has been gained in France on, for example, bogie design, suspension, brake equipment and oscillations, much of which has been incorporated in the most recent units. Similarly, the different methods of mounting the motors are analysed, and motor characteristics, methods of control, and circuit lay-outs are described. A long section is also devoted to the important subject of regenerative braking. A further section covers the power supply system, including substation design and control, especially by remote and automatic methods. M. Louis Armand, Directeur Général de la Société Nationale Chemins de Fer Francais, expresses a sound opinion when he states, in the introduction, that this book will be welcomed in technical circles.

11-KV OUTDOOR FUSE-SWITCH FOR RING MAINS.

THE accompanying illustration shows an 11-kV outdoor unit for ring mains, which is now being manufactured by Messrs. Ferguson, Pailin, Limited, Higher Openshaw, Manchester, 11. It is an oil-immersed fuse-switch which can be fitted with two cable boxes mounted individually, or with ring-main oil-immersed switches on each side. Its three-phase short-circuit rating is 250 MVA at 11 kV, the fuse-switch itself having a current-carrying capacity of 200 amperes, while that of the oil-immersed wing switches is 400 amperes. It consists of a welded steel tank with a hinged access cover and is supported on a fabricated angle-iron framework. The fuse links are contained in tubular carriers with contacts at each end, the three-phase assembly being operated by a self-contained spring-loaded mechanism. The fixed contacts are carried on bushings which project into the cable box and the fuses are closed on to them by a handle, the arrangement being that if one fuse blows all three phases are opened by tripping levers.



The cable boxes, which are fitted with gland plates and covers, are attached to the tank. Interlocks are provided so that the hinged cover can only be opened when the fuse-switch is "off." In the open position the mechanism is held tripped and the fuse carriers protrude through openings in an earthed metal screen, so that the links and upper contacts can be inspected. An attempt to reclose the equipment on a "blown" link will trip the mechanism before the switch makes contact.

The oil-immersed switches, which are mounted at each side of the fuse-switch, are of the quick-break type and are operated by a captive handle. The associated mechanism can be locked in the "on," "off" or "earth" positions, movement from "on" to "off" and "off" to "earth" being arranged to take place over the same arc of travel by disengaging and re-locating the operating handle. Inadvertent operation from "on" to "earth" is thus prevented. Interlocks are also fitted so that the test orifice cover cannot be opened unless the switch is earthed; and the switch is locked in this position when the cover is removed. A current-potential testing device is provided which, when inserted, allows the switch to be operated only to the "off" position. The device itself is then automatically locked in the spouts and connected to the cable contacts.

JUNCTION BOXES FOR UNDERFLOOR DUCT SYSTEMS.—The General Electric Co., Ltd., Kingsway, London, W.C.2, have introduced a new type of junction-box for use with underfloor duct systems of electric wiring. These boxes, which are available in two sizes, have sides of cast-aluminium alloy with steel-plate bases. Sockets, and up to five duct outlets, are provided in the sides and conduit outlets at each corner.

BOOKS RECEIVED.

Manual on Industrial Water. American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. [Price 4.25 dols.]

Simplified Design of Roof Trusses for Architects and Builders. By PROFESSOR HARRY PARKER. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 32*s.* net.]

Statistics of the Iron and Steel Industries of Oversea Countries for 1951. British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1. [Price 15*s.*]

The Design of Valves and Fittings. By G. H. PEARSON. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 50*s.* net.]

British Railways. Mechanical and Electrical Engineer's Department. Bulletin No. 5. *Performance and Efficiency Tests with Exhaust Steam Injector. British Railways Standard Class* 7 2 *Cyl.* 4-6-2 *Mixed Traffic Locomotive.* The Railway Executive, 222, Marylebone-road, London, N.W.1. [Price 10*s.* net.]

Report of the Fuel Research Board with the Report of the Director of Fuel Research for the Year 1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

B.I.M.C.A.M. The British Industrial Measuring and Control Apparatus Manufacturers' Association, 21, Tothill-street, London, S.W.1. [Gratis.]

Sampling Techniques. By PROFESSOR WILLIAM G. COCHRAN. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 52*s.* net.]

Canada. Department of Mines and Technical Surveys. Mines Branch. The Canadian Mineral Industry in 1950. The Director, Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada. [Price 25 cents.]

The Ohio State University Engineering Experiment Station. Bulletin No. 152. *Analysis of Lubricating Oils.* By PROFESSOR EDWIN E. SMITH and others. The Director, Engineering Experiment Station, Ohio State University, Columbus, Ohio. [Price 2 dols.]

Portugal. Ministério das Obras Públicas, Laboratório Nacional de Engenharia Civil. Publication No. 30. *Estudo da Regularização e Protecção das Barrocas de Luanda.* By ULPIO NASCIMENTO. No. 31. *Note on Differences of Bernouilli and Poisson Variables.* By GUSTAVO DE CASTRO. Laboratório de Engenharia Civil, Av. do Brasil, Lisbon, Portugal.

Supplement to the Catalogue of Lewis's Medical, Scientific and Technical Lending Library. 1950-1952. Lewis's Library, 136, Gower-street, London, W.C.1. [Price 3*s.* net to subscribers, 6*s.* to others.]

TRADE PUBLICATIONS.

Self-Priming Portable Pumps.—Ransomes & Rapier, Ltd., Ipswich, have sent us leaflets describing their self-priming portable pumps arranged for petrol, Diesel, electric or independent drive and mounted on steel or pneumatic-tyred road wheels. The pumps are of the open-impeller type and will pass 25 per cent. of solids in suspension; capacities of the range are from 5,600 to 24,300 g.p.h. with a suction head of 15 ft. and a total head of 50 ft.

Grease-Gun Filler.—An illustrated leaflet sent to us by the Civitas Trading Corporation, Ltd., Wigmore House, 10, Duke-street, London, W.1, describes the "Fill-Gun" which they are marketing. It can be clamped on to a standard 28-lb. keg of grease. The grease-gun with nozzle removed is fitted over the discharge nozzle of the apparatus and two levers either side, working on a rack, are depressed to force the grease into the gun. The advantages of this apparatus are speed and ease of operation coupled with the fact that the grease is not touched by hand or contaminated in any way.

Battery-Charging Control Unit.—Standard Telephones and Cables Ltd., Boreham Wood, Hertfordshire, have sent us a leaflet giving details of their automatic battery-charging control units.

Power Factor Correction Regulator.—A power-factor correction regulator for multi-stage capacitor switching is described in a pamphlet received from Standard Telephones and Cables, Ltd., North Woolwich, London, E.16.

Asbestos Sheet with Metallic Insertion.—The British Reinforced Asbestos Co., Ltd., 24, New-street, Worcester, have sent us a leaflet dealing with the properties of their woven-asbestos sheeting with a metallic insertion. A sample was also attached. This jointing material is flexible and is suitable for use at high pressures and temperatures. It is made in sheets $\frac{1}{16}$ in. and $\frac{1}{8}$ in. thick, and is also available as a tape from 1 in. to 4 in. wide.